Popular Astronomy

Vol. XLVII, No. 8 OCTOBER, 1939 Whole No. 468

The Sixty-Second Meeting of the American Astronomical Society

By CHARLES H. SMILEY

At the invitation of Dr. R. G. Aitken, the American Astronomical Society held its sixty-second meeting at the University of California in Berkeley on August 7-9, 1939. The sessions for papers and the Council Meetings were held in International House and a considerable number of the members were housed there. The comfort and convenience of this arrangement can hardly be exaggerated.

The first gathering of the members was a social one, a delightful tea at the Women's Faculty Club on Monday afternoon by invitation of Vice-President and Mrs. Monroe E. Deutsch of the University. Mrs. W. W. Campbell, Mrs. W. H. Wright, Mrs. R. T. Crawford, and Dean Lucy Stebbins presided at the tea table.

On Monday evening, the members of the Council met in International House while other members of the Society took advantage of the opportunity to visit the Exposition on Treasure Island and to view the beautiful colored lighting effects. The generosity of Dr. Fath in revealing the exposure times which he had used with success enabled the members interested in color-photography to take pictures with confidence.

On Tuesday morning, the first formal session of the Society was held in the Men's Lounge in International House. To an address of welcome by Vice-President Deutsch of the University of California President Aitken replied, seconding the invitation and expressing the pleasure of the society in coming again to Berkeley. There followed a series of invited papers, presented by astronomers from some of the larger western observatories. Dr. Walter S. Adams, Director of the Mt. Wilson Observatory, spoke on "Spectra of Bright Stars Observed with High Dispersion," and told of the successful use of highly efficient modern spectrographs at Mt. Wilson. This was followed by a paper on "The 200-inch Telescope" presented by Dr. John A. Anderson, Executive Officer of the Observatory Council of the California Institute of Technology.

Dr. Russell Tracy Crawford, Director of the Students' Observatory of the University of California, spoke in a modest but effective way on the "Contributions of the Students' Observatory to Astronomy." At the end of the paper, Dr. Aitken asked all of the astronomers present who had received training at the Students' Observatory to rise. There seemed to be more members standing than seated.

A paper prepared by Assistant Director Joseph A. Pearce on "Re-

searches in Progress at the Dominion Astrophysical Observatory" was read by Dr. Andrew McKellar. Dr. Edwin P. Hubble of the Mt. Wilson Observatory spoke on "The Barred Spiral Nebulae," telling of his researches in this field. A paper by Dr. Vesto M. Slipher, Director of the Lowell Observatory, on "The Spectra of Faint Extended Nebulae" was read by Dr. J. C. Duncan. It was announced that a seventh paper, "Recent Work of the Lick Observatory" by Dr. William H. Wright would be presented on Wednesday evening when the members visited the Lick Observatory. By invitation of the Council, Miss Annie J. Cannon presented a paper on "Faint Spectra for the Study of Galactic Structure." Following this interesting paper the morning session was closed.

Members of the Society and guests gathered on the front steps for the usual photograph. Unfortunately some of the members on one side were omitted and a supplementary photograph had to be taken the next day.

After lunch, the business meeting was held and the following officers were elected: Vice-President, Edwin P. Hubble; Secretary, Dean B. McLaughlin; Treasurer, Frank C. Jordan; Councilors, Christian T. Elvey, Charles H. Smiley, and Georg Van Biesbroeck; Representative on the National Research Council, Paul W. Merrill.

At the beginning of the session for papers which followed the business meeting, it was announced that because of the length of the list of papers to be presented and the limited amount of time available, those papers whose authors were present would be read first and that other papers would be read later if time permitted. It seems unwise to attempt to single out certain papers for mention here. Instead let it be said that the quality of the papers presented was so high that members seldom could slip out for a "breather" without missing a really significant paper. The reader may be referred to the abstracts of the papers which will appear in due course in the *Publications of the Society*.

On Tuesday evening the Society Dinner was held in the Auditorium of the International House. There were three excellent after-dinner speeches, one by Vice-President Fox who had flown out from Chicago, one by Dr. Joel Stebbins, and one by Dr. A. O. Leuschner. Dr. Leuschner gave a very interesting account of the difficulties he encountered in his early days in astronomy, mentioning in particular three times when he was "almost fired."

On Wednesday morning after a final meeting of the Council, a session for papers was held. At 12:30 P.M., after a vote of thanks to the hosts and hosts-to-be, the meeting was declared adjourned. The members then gathered at the Claremont Country Club to enjoy a sumptuous luncheon as guests of the astronomers of the University of California. From there, the members went by auto caravan to the summit of Mt. Hamilton where they had an opportunity to inspect by daylight the equipment of the Lick Observatory.

The damage caused by the army airplane crashing into the main building had practically all been repaired. It seemed very fortunate that the only scientific loss was three spectrograms, though a desk in which many spectrograms were housed was smashed and though tens of gallons of gasoline were sprayed about so that a single spark would probably have caused the complete demolition of the observatory.

After a splendid picnic supper thoughtfully provided by the host astronomers, the members gathered in the library to hear Dr. Wright speak on "Recent Work of the Lick Observatory." Then they were privileged to view Mars through the 36-inch refractor. Though the seeing was not up to Mt. Hamilton's best, the visitors were able to see the polar caps and a considerable amount of detail in the equatorial region. Additional entertainment was provided by Dr. Jeffers' motion pictures in color of the Stockholm meeting of the I.A.U. and Dr. Fath's color stills of western scenery.

Some of the members returned to Berkeley for the night, spent Thursday at the World's Fair, and took the train for Southern California in the evening. Others spent the night in San Jose and drove south on Thursday.

Friday was filled with the excursion to Palomar Mountain to see the dome and mounting for the 200-inch reflector. The group also saw the 18-inch, f/2 Schmidt camera, which has been doing such good work, and the dome for the new f/2.5 Schmidt which will have a 48-inch correcting plate and a 72-inch mirror. After a bountiful luncheon provided by the observatory, the visitors were given an opportunity to see the observatory and to hear about its construction. In the middle of the afternoon, the return journey to Pasadena was begun. A considerable number accepted the invitation of Dr. Dinsmore Alter, Director of the Griffith Observatory and Planetarium of Los Angeles, and visited his observatory in the evening. Again they were privileged to see Mars.

The morning of Saturday, August 12, was spent in visiting the optical shop and the machine shop of the California Institute of Technology. In the former, the 200-inch disc, ground and polished in the temporary spherical form and the 120-inch plane mirror which will be used to test the 200-inch were seen, as well as the machines on which the grinding and polishing were being done. The tenth-scale model of the 200-inch was also on exhibition.

The Pasadena offices and shops of the Mt. Wilson Observatory also held open house. The 72-inch mirror of the new Schmidt camera for Palomar Mountain was seen in the process of being ground to form. In the afternoon the members of the Society went by automobile up the splendid new highway to the top of Mt. Wilson. During the daylight hours, they were shown the solar tower telescopes. After an excellent supper provided by the hosts and served out on the terrace near the "Monastery," the visitors were invited to see and *to look through the 100-inch and the 60-inch reflecting telescopes.* Mars was seen in splen-

did detail through the 100-inch. Following this, the nebula NGC 7009 with its interesting form and colors was shown. Through the 60-inch, the visitors saw the Cluster in Hercules and the Nebula in Andromeda. Also of especial interest was the opportunity to see the Moon House and the work of F. E. Wright and Hamilton Wright on the moon.

It was with regret that the members saw the week of meetings and visits to observatories draw to a close. The generous hospitality shown them and the fullness of the meetings made the visitors resolve not to miss the next meeting to be held on the Pacific Coast. Now they are looking forward to the winter meeting of the Society which will be held at the Perkins Observatory at Delaware, Ohio.

PROVIDENCE, RHODE ISLAND, AUGUST 20, 1939.

The Light Curves of Novae

By DEAN B. McLAUGHLIN

INTRODUCTION

Between the lines of many authoritative scientific papers, and especially of most astronomical texts and popular books, one can read the widespread belief that the typical novae are very rapid in their changes. Either explicitly or by implication, Nova Persei 1901 or Nova Aquilae 1918 are named as the typical objects. Differences between these and such slow novae as RR Pictoris 1925 and DQ Herculis 1934 are either not mentioned or are explained away by calling the slow novae "exceptional" or "abnormal." Some stars, because of the slowness of their changes, have not been universally recognized as novae, though it now appears that they belong to that category; other objects have been only grudgingly admitted to the lists.

Another unfortunate misconception is found in the confusion of such objects as Nova Herculis and Nova Aurigae with the recurrent novae. The second brightening of the two objects named was in no sense a second outburst or recurrence; in both cases the second brightening was characterized by the emergence of the nebular spectrum which is typical of the later stages of any nova. A true second outburst would have involved a repetition of the typical sequence of spectral changes associated with the principal maximum of light.

Finally, there has been a great deal of conjecture, misstatement, and erroneous interpretation of observations in connection with the rise from minimum to maximum. These and other errors of fact and flights of fancy will be pointed out in later sections.

In a short paper some three years ago Gerasimovič[1] gave a classifica-

[1] POPULAR ASTRONOMY, **44**, 78, 1936.

tion of novae based on their light curves. The divisions he recognized are as follows:

I. Slow Novae
  Ia. Permanent Novae (P Cygni)
  Ib. Semi-permanent Novae (Eta Carinae)
  Ic. Slow novae proper (Nova Pictoris)
  Id. Slow novae with sudden decline (Nova Herculis).

II. Flashing Novae
  IIa. Flashing Novae proper (Nova Aquilae 1918)
  IIb. Flashing Novae with rapid fall and partial recovery (T Coronae 1866).

In the main this classification is in accord with the writer's views, though it will appear later that class IIb is merely an exaggeration of a feature which is present in the curves of many novae. It will also be shown that there is no clear-cut demarcation between slow and flashing novae, though their taxonomic separation is useful. Gerasimovič also pointed out that slow novae are rather common and he expressed the opinion that they are in no sense abnormal. With this conclusion the writer is in full agreement.

One unfortunate aspect of the state of knowledge of light curves is the tendency to plot each curve so that it will look like that of a "typical nova." Now curves may be made to look like anything,—within limits,—which the draftsman may have in mind, merely by properly choosing the scale. Thus, it is easily possible to make the light curve of Nova Pictoris look surprisingly like that of Nova Geminorum 1912 by compressing the time scale of the former to about one-sixth that of the latter. A person looking casually at the two curves would be struck by their similarity; the same person looking casually at the curves of these two novae plotted to the *same* time scale would be struck by their differences and would remark the "abnormal" character of Nova Pictoris.

The example just given is perhaps not a fair one, since the curves of bright novae are often plotted to several different time scales. But it applies with full force to the fainter objects. The light curves of some faint slow novae have been plotted to scales sufficiently compressed to make them *look* like rapid novae,—and this without even a remark that they were "exceptional." On the other hand, let a *bright* nova put on an identical performance, and on every hand one hears statements about its "abnormal" character. The key to this inconsistency probably lies in the fact that, with the single exception of the "first attempt at their rational classification" by Gerasimovič, no serious comparative study of the curves of novae has ever been published.

The Observational Material

The present investigation has involved the examination and plotting of the original published data on the light variations of all novae discovered since the advent of systematic photography of the sky. Observations of a number of novae are published in *Harvard Annals* 84, and many others are scattered through the *Harvard Bulletins*. The principal

source for each nova will be tabulated in a later section. Rough light curves for the older novae were constructed from the accounts given in the "Geschichte und Literatur" (1915).

The plots were constructed to a few uniform scales. For the rapid novae the early stages were plotted to a scale in which one magnitude was represented by the same distance as ten days; for the slower ones, one magnitude equal to fifty days was used. The later stages of the decline were studied on plots with one magnitude equal to 100 days for both slow and fast novae. In addition, the first few weeks after maximum of the five bright fast novae of the present century were plotted with one magnitude equal to two days.*

About eighty undoubted galactic novae have been recorded since 1572, and there are a couple of dozen suspected objects of various kinds. Probably some of the suspects will eventually be recognized as SS Cygni variables or peculiar variables; some are perhaps true novae for which the data are too scanty to establish their nature. Among the suspects are a few faint ambiguous objects in high galactic latitudes, where even bright novae occur only rarely. It seems at least possible that some of these may be *supernovae* in unrecorded faint extragalactic systems like NGC 6822 and the fainter Sculptor and Fornax systems.[2] The total of authentic galactic novae and all grades of suspects is now about 110.†

In the nature of the case, some of the light curves were found to be very fragmentary, and in some instances there were so few observations that no plots of any value could be made. In view of the uncertainty as to the phases of the variation which were observed in some of these cases, it is necessary to omit them even from a statistical study of magnitudes. Altogether, plots of sixty different novae have been made, including several very sketchy ones. A tabulation of data taken from these curves will be given in a later section.

Typical Light Curves of Fast Novae

The early stages of the light curves of the five bright fast novae of the twentieth century are plotted to two different scales in Figure 1. These curves show strong similarities in several respects. With the exception of Nova Cygni, all rose very rapidly from obscurity to within a couple of magnitudes of maximum and then increased more gradually to greatest brilliance. Each curve has just one principal maximum of light immediately after the steep rise from minimum. On the descending branch all the curves show strong upward concavity, and all except Nova Lacertae exhibited strong fluctuations of light during the decline.

*In the figures reproduced with this paper, a few departures have been made from these scales, owing to the necessity of adjusting the diagrams to the size of the page.

[2] Shapley, *H. B.* 908, 1938; Baade and Hubble, *Publ. A.S.P.*, **51**, 40, 1939.

† Writing in 1935, Lundmark (*Med fr Lunds Astr Obs*, Ser II, No. 74) stated that there were 102 galactic novae. Apparently he regarded all suspects as *bona fide* novae,—surely an unwarranted assumption.

But there are also many noteworthy differences. Nova Cygni's slow rise is unique among the fast novae, so far as we know. The rapidity of increase is particularly well brought out in Nova Aquilae, as is the short pause at magnitude 1.0, before the final increase to maximum. Nova Geminorum was particularly slow in this final rise. Just after maximum, both Nova Aquilae and Nova Geminorum dropped even more rapidly than they had risen, while the others declined more gradually. Nova Geminorum alone showed strong fluctuations of light during the beginning of the decline (one of these was a well-marked maximum ten days after principal maximum); the other four stars faded very smooth-

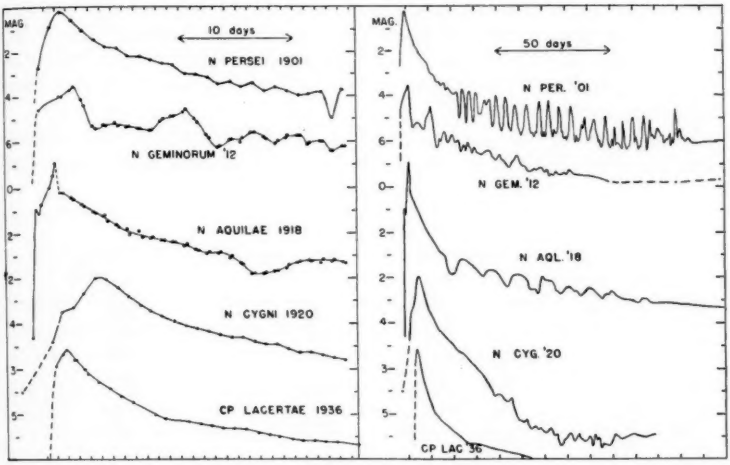

FIGURE 1

LIGHT CURVES OF BRIGHT, RAPID NOVAE IN THE EARLY STAGES, PLOTTED TO TWO TIME-SCALES.

The magnitude scales necessarily overlap. The magnitudes at maximum, in order from top to bottom are: 0.2, 3.5, —1.1, 2.0, and 2.1.

ly through about four magnitudes. But just about four magnitudes below maximum, Nova Persei and Nova Aquilae began to fluctuate violently in a semi-regular manner, and at the same phase Nova Cygni began to decline more rapidly and then varied irregularly through a small range. This type of activity died out at six to seven magnitudes below maximum. Only Nova Lacertae, whose curve is not completely shown, continued to fade smoothly.

All of these variations should be physically explicable if we had the clues or, having them, if we use them correctly. Changes of intensity of the absorption spectra have been found to be correlated with the fluctuations of light, and the nebular emissions emerge conspicuously during

the stage of strong fluctuations from four to six magnitudes below maximum.

Some Misinterpretations of Observations

Before we can arrive at a general idea of the nature of the light curves of slow novae, it is necessary to draw attention to some errors in the interpretation of data which may easily be perpetuated for many years if they are not specifically pointed out. In several cases of which we have only fragmentary records, the time of maximum observed brightness has been preceded by a long interval in which no observations were obtained. Some of these were slow novae, and, since the last magnitude or two of the rise to maximum was slow, it might be inferred that the star took a long time to come up from minimum. Indeed, the statement has actually been published that Nova Circini 1906, Nova Scorpii 1906, and Nova Sagittarii 1910 took respectively 6, 10, and 8 *months* to rise from minimum to maximum.

That there may be no possibility of misunderstanding, the original data are reproduced here. In Table I, typical *selected* observations of

TABLE I

Magnitudes of Slow Novae

Nova Circini 1906		Nova Scorpii 1906		Nova Sagittarii 1910		X Serpentis 1903	
J.D.	Mag.	J.D.	Mag.	J.D.	Mag.	J.D.	Mag.
6166	15.0	4457	<15.5	7773	16.5	4884	14.3
6254	15.0	7094	<14.1	7801	16.3	5090	<14.8
6268	<14.4	7124	<12.0	8530	<15.1	5599	<15.4
6646	<14.4	7325	11.60	8571	<13.0	5897	<13.6
7037	<13.5	7335	12.15	8587	<10.5	5910	<12.2
7077	<13.2	7353	11.80	8594	10.30	5937	11.6*
7087	<12.7	7360	12.10	8752	9.50	5976	<12.8
7094	<12.7					5998	<11.2
7238	11.5					6170	9.1
increase follows to 10.3		increase follows to 9.7		increase follows to 8.1		decline follows	

*Image present, poor.

each star are given for the pre-nova stage, and the *complete* data are included for the 6, 10, and 8 month intervals preceding the first plate showing the star bright. The data for an additional star, X Serpentis, are also given. All these observations are from *Harvard Annals,* Vol. 84.

In the original publication the symbol < for "fainter than" was not used; instead the magnitude indicating the plate limit was printed in italics. Now, it is noticeable that in all three cases *the plate limit happened to get brighter* during the months just preceding the outburst of the nova. Evidently the italics were misinterpreted as actual *observed magnitudes* of the novae! In none of these cases is there the slightest evidence that they brightened slowly through more than the last two magnitudes or so below maximum. It will be shown later that this portion of the rise may be quite slow, even though the earlier portion of the increase occurred with great rapidity. The assumption that the slow rise

through the last two magnitudes indicates a slow increase all the way from minimum is entirely unwarranted, and is actually refuted by observations in every case in which data are available at the crucial times.

The case of Nova Pictoris is of special interest. It was photographed as a third magnitude star six weeks before discovery, and after discovery it required about two weeks to rise through one magnitude to maximum. An outline of the relevant data is given in Table II.

TABLE II

THE RISE OF NOVA PICTORIS

Date	Mag.
1924, Dec. 26	12.7*
1925, Jan. 13	<11
Feb. 18	<12
Apr. 13	3
May 21	Note
May 25	2.3
Increase follows to	
June 8	1.2

*Normal minimum light.

Note: Reid believes he would have seen it if >6.0.

It will be seen that we know practically nothing of the early portion of the increase of light, except that it took less than eight weeks! It is possible that the increase to third magnitude occurred in a few days. A decline probably followed, though it is difficult to believe that it dropped as low as $6^{M}.0$. Then, after some weeks the star began its final rise to principal maximum. The very prolonged halt before the final increase is simply an exaggeration of the pause shown by Nova Aquilae and abundantly attested by slow novae.

There is no record of any typical nova performing its whole rise from minimum to maximum very slowly. The slowest recorded increase is, ironically, that of the rapid Nova Cygni 1920, which took a week to rise through the last five magnitudes. We should note here that the RT Serpentis stars, which are novae, do rise much more slowly, but we are not yet ready to admit that they are typical novae.

TYPICAL LIGHT CURVES OF SLOW NOVAE

The light curves of the four novae for which data are given in Table I, and of Nova Pictoris and Nova Herculis, are reproduced in Figure 2. In each of these curves there has been a certain amount of reconstruction. Thus, the initial rise of both Nova Pictoris and Nova Herculis are represented as being very rapid. The reasons for adopting this interpretation are set forth in the preceding section. In the case of Nova Herculis, we have also the testimony of T Aurigae which rose very rapidly to within two magnitudes of maximum and which duplicated almost exactly every observed characteristic of Nova Herculis. A further argument for great rapidity of increase is found in the high velocities re-

corded on the first spectrograms of Nova Herculis. These imply a very violent outrush of gases in the early stages. One more bit of evidence, though wholly of a negative nature, should also be mentioned. It is possibly significant that Nova Herculis was discovered in the *morning* sky, despite the fact that it was in equally good position in the evening and that there were probably more observers at work the evening before. One is tempted to conclude that it was not discovered twelve hours earlier, simply because *it was not there!*

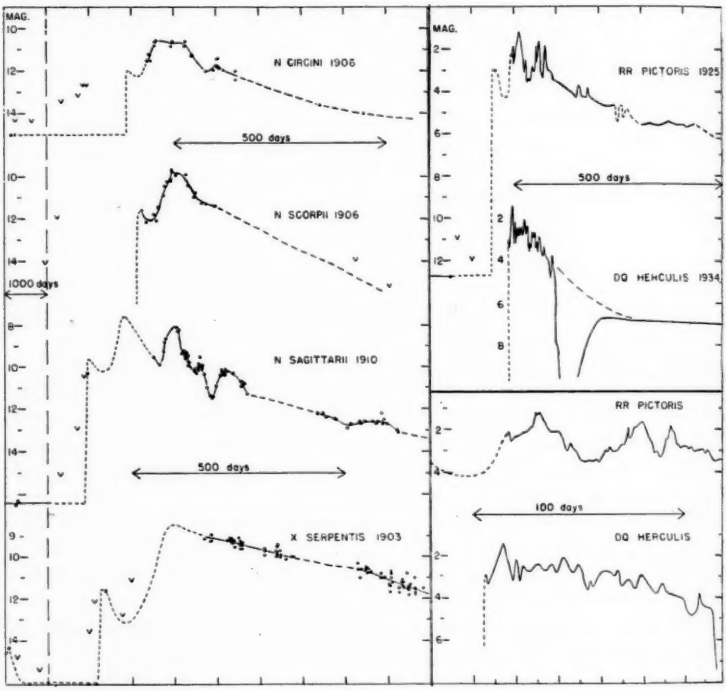

FIGURE 2

LIGHT CURVES OF SLOW NOVAE.

Note the small-scale interval of 1000 days at the left. All are plotted to the same time scale, and Nova Herculis and Nova Pictoris are repeated on a larger time scale at the lower right.

The curves of the other four novae have been reconstructed in terms of the testimony of the two bright ones and of some others which are not so well known.[3] Thus, a pause on the ascent is shown in each curve,

[3] For example: v356 Aquilae (1936), POPULAR ASTRONOMY, **45**, 219; Nova Ophiuchi No. 4, (1919), *Publ. A.S.P.*, **33**, 190, 1921.

because it is usually found when observations are available at the right times. In particular, the observations of X Serpentis seem to demand a decline of over a magnitude before the final rise to maximum. There is, of course, no assurance that the observed maximum of either Nova Circini or Nova Scorpii was the principal one; possibly these are secondary maxima, the principal one having been completely missed. This is pretty surely the case with Nova Sagittarii, as one positive observation shows it bright, and then there is a gap of 150 days, after which the star rose to its first *recorded* maximum of light.

Lest an earlier remark concerning "flights of fancy" become a boomerang, let it be said here that these reconstructions are defensible on the ground that they merely ascribe to the incompletely observed novae the same characteristics that have been found in others which were better observed at the crucial phases. No new character of a speculative nature has been introduced. The assumption that some novae have come up slowly from minimum cannot be defended in this way; it is refuted by observation in every case that has been well observed. Even Nova Cygni, which has the distinction of having the slowest recorded rise, was already nine magnitudes above minimum when first observed. It is admitted that the RT Serpentis stars increase more slowly.

The tendency of these slow novae to fluctuate irregularly during the early part of the decline is particularly marked. The same characteristic was exhibited by v356 Aquilae (1936). Some cases of smooth decline are known among the slow novae (X Serpentis and Nova Normae 1893) but they seem to be the exception rather than the rule. Among the fast novae, we recall that Nova Geminorum 1912, the slowest of the five bright ones, was noteworthy for its fluctuations just after maximum; Nova Lyrae 1919 was probably a parallel case. Evidently the slower a nova is, the more likely it is to vary irregularly.

The deep minimum of Nova Herculis has a parallel in two other cases: T Aurigae 1891 and Nova Sagittarii 1936.32.[4] It set in at about four magnitudes below maximum and the recovery brought the star to about six magnitudes below maximum. At a corresponding stage, Nova Pictoris showed some revival of irregular fluctuations, and we recall the irregular fluctuations or fadings below the smooth curve in the fast novae at the same phase (expressed in terms of magnitudes below maximum). Thus, we can recognize certain common characteristics in the curves of fast and slow novae, and the conviction that they are fundamentally alike is strengthened.

Stages of the Light Curves of Novae

The foregoing discussion has brought out similarities and differences between the light curves of these stars. The comparison of curves leads to the recognition of several distinct stages of the light variation of a

[4] *Harv. Bull.* 907.

typical nova. For purposes of discussion we shall accept these natural subdivisions. Although some of these stages appear to be lacking in specific cases, there is some reason to attribute this to observational difficulties rather than to real departure from the normal sequence of events.

The several divisions will be briefly described.

(1). *The pre-nova stage.* During this portion of its life, the star is either constant or irregularly variable through a small range.

(2). *The initial rise.* This is that portion of the increase of light from minimum to a brightness roughly two magnitudes fainter than maximum light. This is always accomplished with great rapidity, except in the RT Serpentis stars.

(3). *The pre-maximum halt.* In several well-authenticated cases, one of which is the fast Nova Aquilae 1918, the initial rise has been followed by a marked pause or even a fading of the star. The duration of this stage is relatively short in most cases, but was quite prolonged in Nova Pictoris. In most of the fast novae it has been slurred over.

(4). *The final rise.* This includes the increase of light from the pre-maximum halt to maximum light. It occurs much more slowly than the initial rise. Most of the bright novae have been discovered very close to the beginning of this stage.

(5). *The maximum of light.* In all but a very few cases, there is *one* principal maximum of light, though it may be followed by lesser secondary maxima. Its duration is relatively brief except in the atypical RT Serpentis stars.

(6). *The early decline.* This stage is considered to extend from maximum light down to three or four magnitudes below maximum. The decline may be smooth or marked by strong fluctuations, some of which may produce secondary maxima nearly comparable with the principal one. The most rapid novae especially seem to decline very smoothly. In considering the fluctuations during the *early decline* we must carefully avoid confusing them with the variations which characterize the next stage. Thus, the strongest oscillations of Nova Pictoris were not at all to be compared with those of Nova Persei 1901. In the first case, the variations were during the early decline; in the other they were during the next stage, which is called *the transition.*

(7). *The transition.* This stage sets in at about 3.5 magnitudes below light maximum. It is here that novae exhibit their greatest individual differences. The transition takes one of three forms: (a) a series of strong oscillations; (b) a single broad minimum of very different depth in individual cases, followed by a recovery of light; (c) an abrupt change of the curve towards a gentler slope. At the end of the transition, the star is about six magnitudes fainter than maximum.

(8). *The final decline.* Following the conclusion of the transition,

the nova fades slowly and uneventfully to the pre-nova magnitude. Oscillations during this stage are usually small and irregular.

(9). *The post-nova stage.* After the star has reached its original pre-nova brightness it may be constant in light or it may vary irregularly through a small range. In the repeating novae, of course, the post-nova stage of one outburst merges into the pre-nova stage of the following one.

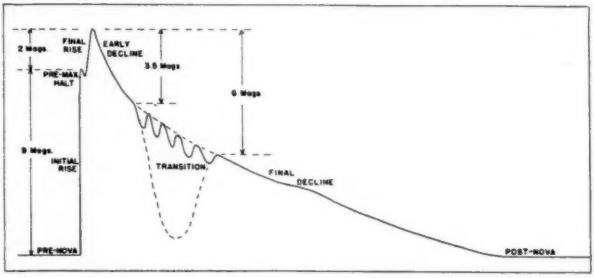

FIGURE 3

SCHEMATIC LIGHT CURVE OF A NOVA, SHOWING TYPICAL STAGES. The time scale is not uniform throughout; it has been magnified in the early stages.

In succeeding sections we shall discuss each of these stages in somewhat greater detail and point out specific examples of each type of behavior. Figure 3 represents an idealized light curve of a nova with the several stages labelled. The three alternatives at the transition are indicated.

(To be continued)

Upper Atmosphere Densities and Temperatures from Meteor Observations

By FRED L. WHIPPLE

Since February, 1936, the observing programs of two patrol cameras at the northern stations of the Harvard College Observatory have been synchronized for the purpose of photographing meteors simultaneously. One camera is located at Cambridge and the other, 38 km away, at the Oak Ridge Station. The large base line provides accurate triangulation in the determination of the position in space of any point in a meteor trail. At first the Oak Ridge camera was equipped and now both cameras are equipped with rotating shutters operated by synchronous motors. These shutters break the photographed trails into segments equally spaced in time, so that the angular velocity of the meteor may be measured directly at any point of the trail. By triangulation the distance and

direction of motion are known; the linear velocity and deceleration may then be calculated. Twenty-three meteors have been doubly photographed in about 2500 hours total exposure time.

The principal aim of the photographic meteor investigations was originally to determine precise spatial orbits of sporadic meteors in order to make certain whether they belong to the solar system or come from interstellar space. Preliminary results indicate that they are generally, if not always, members of the solar system. It was found that the observed data could be used to determine accurately the densities of the earth's

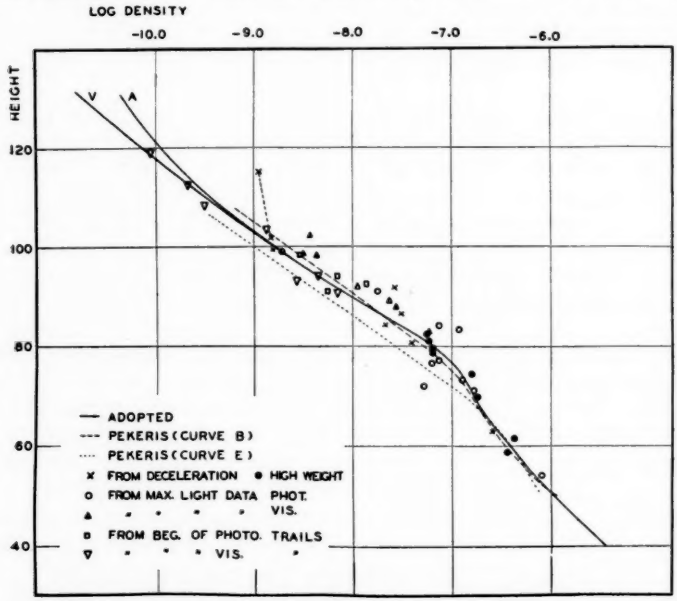

FIGURE 1

upper atmosphere at heights of from 50 to 100 km. A theory for these determinations has been presented by the author;[1] it is based upon the theories by Öpik[2] and Hoppe.[3] In principle the method may be explained as follows: the integrated light of a meteor with a known velocity is a direct measure of the meteor's original mass, if we assume the luminous efficiency from physical theory. The instantaneous brightness is taken to be proportional to the rate of loss of meteoric matter, the light being emitted when atoms evaporated from the body by friction collide with air molecules away from the main body of the meteor. Thus it is possible to calculate the mass of the meteor at any point of its photographed trail. The observed deceleration at a given point then measures the resistance of the atmosphere to a rapidly moving body of known mass,

from which data the density of the atmosphere at that point can be calculated. Uncertainties concerning the composition and shape of the meteoroid do not affect the numerical results seriously.

The accurate reduction of the photographic meteor trails requires considerable measurement and calculation so that only ten meteors are as yet completely reduced. The present results, however, give considerable information concerning densities in the earth's upper atmosphere. It is hoped that within a year the material now available will be reduced, after which a critical study of the theory and the physical constants can be made. The most reliable density determinations (circled crosses and crosses in Figure 1) depend upon the measures of deceleration by the method outlined above. When connected by dashed lines the crosses represent a range in solution caused by uncertainty in the time of appearance of the meteor. The two lower crosses at about the 100-km height represent the range of an elliptic solution for one meteor; hyperbolic solutions were also possible from the direct observations of this meteor.

Less reliable, but still consistent, density determinations (circles in Figure 1) can be obtained from the heights at which maximum luminosities occur for the various meteors. The height at which a meteor of a calculated mass and velocity will attain its maximum luminosity depends, of course, upon the density of the atmosphere. Instead of the deceleration, the height of maximum light can thus be used to determine the atmospheric densities.

A third method, less precise than these two, has also been used. In the early part of a meteor's trail, after evaporation of the surface material has begun but before appreciable mass has been lost, the rate of loss of mass and therefore the luminosity is directly proportional to the air density; the deceleration is here observed to be negligible. For a meteor of a known mass, the air density can thus be calculated directly from the luminosity. This method is useful at greater heights than the deceleration method but is, unfortunately, less reliable, because the air density depends analytically upon the first power of the meteor's luminosity, the least accurately observed datum. In the deceleration and maximum-light methods the luminosity enters only to the one-third power. In Figure 1, the hollow squares identify densities determined from the luminosity in an early part of each meteor trail.

The last two methods, which do not depend upon deceleration measures, have been applied to the visual shower meteors observed by the Arizona Expedition for the Study of Meteors and reduced by Öpik.[4] It was assumed that the mean heights observed for the visual meteors corresponded to the points of maximum luminosity and that the meteors were first observed at visual magnitude +4.0. The luminous efficiency of the visual meteors was taken to be constant with velocity, rather than directly proportional to the velocity as for the much brighter photographic meteors. The air densities calculated from the mean heights are indi-

cated by erect triangles in Figure 1, and those from the beginning heights as inverted triangles. Considerable uncertainty is involved in the calculation of these densities.

The density of the atmosphere at any level depends upon the temperature there and at all levels below. The total mass in a column of given cross-section is determined by the barometric pressure at sea-level, so that the density at the given level depends upon how the whole column is supported. The introduction of a higher temperature layer at a low level would tend to raise the upper part of the column and thus increase the density at all higher levels. In a region of high temperature the logarithm of the air density decreases slowly with height; in a region of low temperature it decreases rapidly. In Figure 1 a steep slope in the log-density curve indicates a higher temperature than a flat slope. The actual curves in Figure 1 were calculated from the corresponding tem-

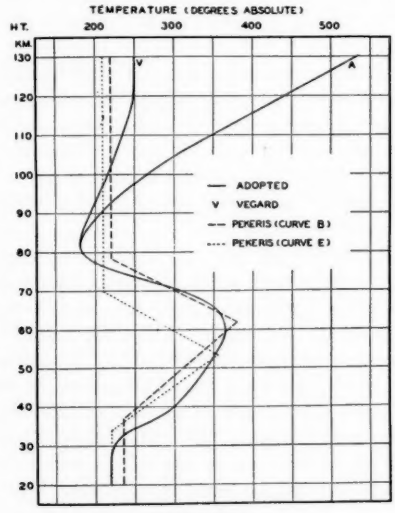

FIGURE 2

perature curves of Figure 2. It was assumed that the atmosphere is homogeneous in composition with a molecular weight of 28.8 (mostly molecular nitrogen) and that at 20 km the pressure is 41 mm of mercury at a temperature of —58° C. The two temperature curves in Figure 2 by Pekeris[5] were based upon a theory of atmospheric oscillations. The "adopted" curve to 50 km is based on F. J. W. Whipple's[6] determinations of temperatures by the speed of sound from gun fire. A maximum temperature has been assumed at 60 km. The minimum at 82 km is assumed because this is the mean level of the noctilucent clouds which may be due to water-vapor condensation at a low temperature. Above this

level the temperature must again rise to attain the higher temperatures calculated from the nitrogen band spectrum of the aurora. The lower-temperature curve passes through Vegard's[7] value of the auroral temperature and the upper-temperature curve through Rosseland and Steenholt's[8] correction to his value.

The temperature maximum near 60 km is confirmed by the steep slope of the log-density curve at this height and by the numerical values of the density. The observations would suggest that perhaps the layer of maximum temperature is thicker than was assumed in the "adopted" temperature curve and that the temperature minimum occurs at a higher level than 82 km. A subsequent rise in temperature at greater heights is clearly shown by the slope of the observational curve, but the accuracy is not sufficient for an exact evaluation of the rate of rise. In general, the agreement between the adopted and observed curves is so close that the author does not wish to correct the "adopted" curve until more material has been analyzed, and until the physical theory of a meteor's luminous efficiency has been reconsidered.

The temperature inversion above 60 km is verified by independent observations of meteor light curves. From the photographic meteor trails in the Harvard plate collection Miss Hoffleit[9] observed that the faster shower meteors attain their maximum brightness nearer the ends of their trails than do the slower meteors. Her results are quantitatively explained by the present theory of the meteor phenomenon, coupled with the temperature inversion above 60 km as represented by the "adopted" temperature and density curves of Figures 2 and 1. The explanation follows simply. When a meteor is evaporating by its passage through the atmosphere the rate of evaporation, and therefore the luminosity, depends directly upon the air density and upon the meteor's cross-section. At first the loss of mass is small and the rate of increase of brightness depends only upon the rate of increase in the air density. Eventually the meteor decreases in size until the rate of decrease in cross-section matches the rate of increase of air density. At this point maximum light is attained. Deceleration has little numerical effect in the theory until after maximum light.

For meteors of the same luminosity the faster ones will attain maximum light at greater heights than the slower ones. The faster meteors happen to occur in the low-temperature region of the atmosphere where the logarithmic density gradient is great. Consequently they continue to increase in brightness until near the ends of their trails where the rate of decrease in cross-section is great enough to match the rapid increase in air density. The slower meteors occur at lower levels where the temperature of the atmosphere is greater and the logarithmic density gradient is smaller. The decrease in cross-section dominates the light curve at an earlier stage and maximum light occurs relatively earlier in the trail, as was observed by Miss Hoffleit.

The effect is illustrated in Figures 3a-b where theoretical light curves

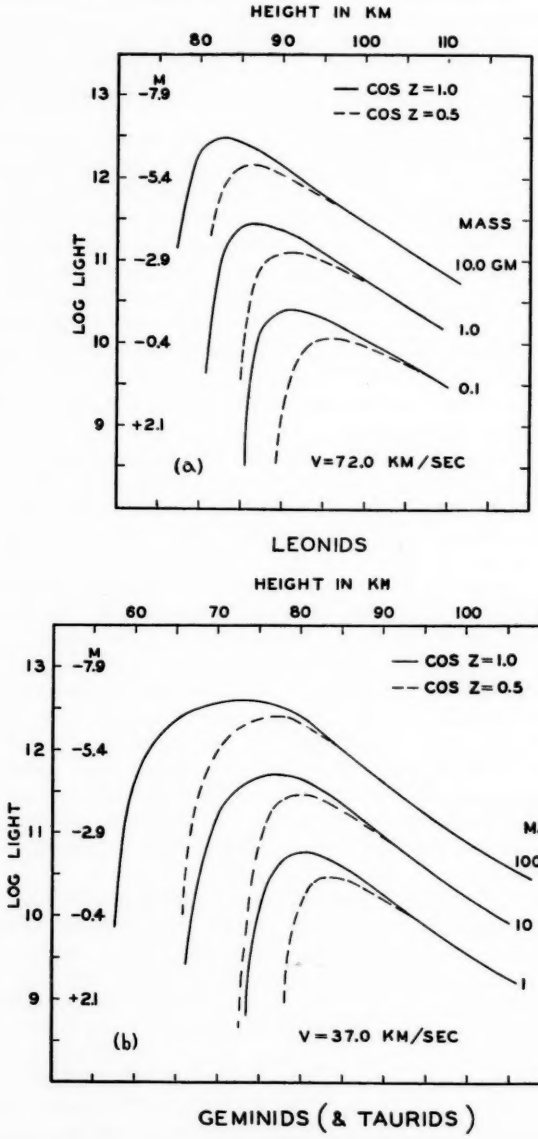

FIGURE 3

THEORETICAL LIGHT CURVES

for the Leonid and for the Geminid (and, roughly, for the Taurid) meteors of various masses are reproduced. The calculations were based on the theory adopted by the author,[1] and were made for two values of the cosine of the zenith distance of the radiant (cos Z). For an homogeneous and isothermal atmosphere all the light curves would be similar in shape, but would, of course, be displaced vertically and horizontally for different values of the initial mass and velocity; a change of cos Z or of atmospheric temperature would produce only a change in scale and would not affect the relative position of the point of maximum light.

REFERENCES

[1] *Proc. Am. Phil. Soc.*, **79**, 499, 1938.
[2] *Har. Reprint* 100, 1933; *Pub. Obs. Ast. Tartu*, **29**, 1937.
[3] *A. N.*, **262**, 169, 1937.
[4] *Har. Ann.*, **105**, 549, 1937.
[5] *Proc. Roy Soc. A*, **158**, 650, 1937.
[6] *Quart. J. Roy. Met. Soc.*, **57**, 331, 1931; **58**, 471, 1932; and **60**, 80, 1934.
[7] *Nature*, **138**, 930, 1936.
[8] *Pub. Univ. Obs. Oslo*, No. 7, 1933.
[9] *Proc. Nat. Acad. Sci.*, **19**, 212, 1933.

The Calculation of Meteor Orbits

(FORMULAS)

By C. C. WYLIE

The majority of modern papers on orbit calculation contain little of interest to the real expert in Celestial Mechanics. Moulton[1] comments on the work of Laplace and Gauss of more than 100 years ago, and then adds "In spite of the hundreds of papers which have been written on the theory of the determination of orbits, very little that is really new or theoretically important has been added to the work of Laplace and Gauss unless more than three observations are used." Modern writers, however, have developed formulas and computed tables which give greater convenience in computing, or better differential corrections. Merton's modification of the method of Gauss, and Leuschner's modification of the method of Laplace, have been found quite useful by computers.

In our work on meteor orbits, we have taken basic formulas from standard works and have rearranged them, developed new formulas, and prepared tables where it appeared that greater convenience or simplicity could be attained. Our method has been developed while computing to meet the needs of the computer.

THE STEPS IN DETERMINING A METEOR ORBIT

If we assume that the apparent radiant and apparent velocity of the meteor are known, the computation of the orbit can be outlined as follows: first, the obtaining of the geocentric radiant and velocity; second,

[1] Moulton, F. R., "Celestial Mechanics," revised edition, pp. 193-194.

the obtaining of the heliocentric radiant and velocity; and third, the calculation of the elements of the orbit. For step one and step two, the basic formulas were taken from Moulton's "Celestial Mechanics," Bauschinger's "Bahnbestimmung der Himmelskörper," and Olivier's "Meteors." For step three, the computation of the elements of the orbit, the basic formulas were taken from Moulton's "Celestial Mechanics," Williams' "The Calculation of the Orbits of Asteroids and Comets," and Crawford's "Determination of Orbits of Comets and Asteroids." The technical terms used in this paper are explained in any of the books cited.

The Fundamental Methods in Orbit Calculation

Modern methods in the computation of asteroid orbits are based, as we have said, on the fundamental work of Laplace and Gauss. The Laplacian method reduces the observational data to the three coördinates of the body, and the three components of velocity at the time of the second observation. The Laplacian method obtains one complete position and the velocity, and from these obtains the elements of the orbit. The Gaussian method reduces the observational data to the three coördinates of the body at the times of the first and third observations. The Gaussian method obtains two complete positions, and from these obtains the elements of the orbit. For meteor orbits, it is obvious that the Laplacian, rather than the Gaussian, method should be used. The heliocentric coördinates and velocity of the meteor, as obtained in step two of the preceding paragraph, give essentially one position and the velocity, the intermediate step in the Laplacian method. Of the reference books cited for step three, the last named gives the most nearly complete set of formulas for the Laplacian method.

The formulas for a general orbit can be simplified in meteor work because of the following considerations: (1) At the time of its fall, a meteor has the same heliocentric coördinates as the earth; (2) it is in the plane of the ecliptic, at one of the nodes of its orbit; (3) the longitude of the node is 180° plus the longitude of the sun; (4) the "argument of the latitude" counted from this node is zero; (5) the longitude of perihelion, counted from this node, is the negative of the true anomaly.

The Notation

Let us use the following notation, which is standard in meteor work and in orbit work.

w = Apparent velocity of meteor
$V_2 = u$ = Geocentric velocity of meteor
$V = v$ = Heliocentric velocity of meteor
V_1 = Velocity of earth in its orbit
V_i = Velocity from infinity for the earth
z = Apparent zenith distance
Δz = Correction for zenith attraction
t = Hour angle
α = Right ascension

δ = Declination
ϕ = Latitude
x, y, z = Heliocentric rectangular coördinates of the earth
r = Distance of earth from sun
X, Y, Z = Geocentric rectangular coördinates of sun
V_x, V_y, V_z = Rectangular components of V
a = Semi-major axis of orbit
v = True anomaly
e = Eccentricity
ω = Longitude of perihelion from node
i = Inclination of orbit
Ω = Longitude of node
P = Period

As we have indicated previously, we are assuming for the meteor a well-determined path through the atmosphere, and a duration, or other data, from which the velocity can be determined. In other words, we are assuming the apparent radiant and the apparent velocity. We are assuming also some familiarity with the fundamentals of orbit work, so that the derivation of the formulas can be obtained, if desired, from the reference books we have cited.

The Heliocentric Coördinates and Velocity of the Earth

The heliocentric coördinates of the earth are:

$$x = -X$$
$$y = -Y$$
$$z = -Z$$
$$r = \quad r$$

The quantities X, Y, Z are the rectangular coördinates of the sun, taken from the *American Ephemeris* for the time of fall of the meteor. The quantity r is the distance of the earth from the sun, taken from the *Ephemeris* for the same time.

The approximate velocity of the earth is 18.5 miles per second. The approximate coördinates of the apex of the earth's motion can be obtained as follows. The longitude of the sun is taken for the time of fall of the meteor, and 90° subtracted. The right ascension and declination of the sun are taken for a time about three months earlier, when the sun had exactly that longitude. This procedure is sufficiently accurate for ordinary visual work, but the error due to the eccentricity of the earth's orbit may be nearly a degree in the longitude of the apex, and about 0.3 mile in velocity.

For more accurate work, Table I[2] can be used, which is little more laborious than the approximate method. The velocity of the earth in its orbit, V_1, and a correction to the longitude of the sun, ΔL, are tabulated for 0^h Greenwich Civil time on the first day of each month.

The procedure with Table I is as follows: Take the velocity V_1, and the correction ΔL from the table, interpolating for the time of fall of the meteor. From the *American Ephemeris*, take the longitude of the sun for the time of fall, and subtract ΔL. The right ascension and declination of the sun are then taken for a time about three months earlier when the sun had exactly that longitude.

The components of the earth's motion are obtained from this right ascension and declination, and the velocity V_1, as follows:

$$V_{x_1} = V_1 \cos \alpha \cos \delta$$
$$V_{y_1} = V_1 \sin \alpha \cos \delta$$
$$V_{z_1} = V_1 \sin \delta$$

The Geocentric Radiant and Velocity of the Meteor

The apparent radiant of a meteor is displaced by the rotation of the earth, the displacement being termed diurnal aberration, and by the gravitational attraction of the earth, this displacement being termed zenith attraction. The apparent velocity is increased by the gravitational attraction of the earth.

The formulas for diurnal aberration are:

$$\Delta\alpha^\circ = -(16.50/w) \cos \phi \cos t \sec \delta$$
$$\Delta\delta^\circ = -(16.50/w) \cos \phi \sin t \sin \delta$$

where w, the apparent velocity, is expressed in miles, and the corrections $\Delta\alpha$ and $\Delta\delta$, in degrees. These corrections are usually less than a degree, and often are neglected, but for well-observed fireballs they should be included.

The formulas for zenith attractions are:

$$\tan (\Delta z/2) = M \tan (z/2)$$

and

$$w^2 - u^2 = V_i^2$$

where z is the apparent zenith distance, Δz is the zenith attraction, V_i is the velocity from infinity for the earth, and

$$M = (w - u)/(w + u).$$

Table II[2] gives the value of $w - u$ and M, with w as argument. With this table, the geocentric radiant and velocity are obtained as follows. With w, the apparent velocity, take out M, and obtain Δz from the above formula. The geocentric zenith distance is obtained by adding Δz to z. With the same argument take out $w - u$. The geocentric velocity is obtained by subtracting this quantity from w.

If the more extensive tables[3] prepared by Axel V. Nielson are at hand, u and Δz can be taken out directly, provided w and u are expressed in kilometers.

The altitude and azimuth of the geocentric radiant are reduced to right ascension and declination by the usual formulas of practical astronomy. Since the meteor moves away from the radiant, the components of the geocentric velocity are the negative components in the direction of the radiant. That is:

$$V_{x_2} = -u \cos \alpha \cos \delta$$
$$V_{y_2} = -u \sin \alpha \cos \delta$$
$$V_{z_2} = -u \sin \delta$$

---

[2] To appear in "The Calculation of Meteor Orbits (Tables)," in the succeeding issue of Popular Astronomy.

[3] *Meddelser fra Ole Rømer Observatoriet*, No. 12, November, 1938, i Aarhus, Denmark.

THE HELIOCENTRIC COÖRDINATES AND VELOCITY OF THE METEOR

The heliocentric coördinates of the meteor at the time of its fall are x, y, and z, the coördinates of the earth at that time. The distance of the meteor from the sun is r, the distance of the earth from the sun. Directions for obtaining these quantities were given under "The Heliocentric Coördinates and Velocity of the Earth."

The components of the heliocentric velocity of the meteor are obtained by addition, as follows:

$$V_x = V_{x_1} + V_{x_2}$$
$$V_y = V_{y_1} + V_{y_2}$$
$$V_z = V_{z_1} + V_{z_2}$$

As we stated before, the components of motion of a meteor are the negative of components in the direction of the radiant. Hence the right ascension and declination of the heliocentric radiant, and the heliocentric velocity of the meteor, are obtained from the formulas:

$$V_x = -V \cos \alpha \cos \delta$$
$$V_y = -V \sin \alpha \cos \delta$$
$$V_z = -V \sin \delta$$

The solution of these gives α, the right ascension, and δ, the declination, of the heliocentric radiant, and V, the heliocentric velocity.

Let

$$f = s/Rk$$

where s is the number of seconds in a day, R is the mean distance of the earth from the sun expressed in miles, and k is the Gaussian constant. Then

$$f = 5.4067 \times 10^{-3}$$
$$G = fV$$
$$x' = fV_x$$
$$y' = fV_y$$
$$z' = fV_z$$

Solve for r', from the equation

$$rr' = xx' + yy' + zz'$$

where r' is the only unknown.

THE ELEMENTS OF THE ORBIT OF THE METEOR

We now have the heliocentric coördinates of the meteor at the time of its fall, and the components of its heliocentric velocity. We have reached the intermediate step in the Laplacian method, so we are ready to determine the elements of the orbit.

Solve for a from the equation

$$1/a = 2/r - G^2.$$

Solve for p from the equation

$$p = r^2[G^2 - (r')^2].$$

Solve for e, v, and ω_1 from the equations

$$e \sin v = r' \sqrt{p}$$
$$e \cos v = p/r - 1$$
$$\omega_1 = -v$$

As a check on the calculation of p and e, compute a from the equation

$$a = p/(1-e^2).$$

Obtain Ω_1 from

$$\Omega_1 = (\text{longitude of sun}) + 180°.$$

Obtain i_1 from the equation

$$\sin i_1 = (0.9174/\sqrt{p})(rz' - zr') + (0.3979/\sqrt{p})(yr' - ry').$$

The quantities 0.9174 and 0.3979 are the cosine and sine respectively of the obliquity of the ecliptic. The figure for the cosine is correct to four significant figures for the approximate period 1840 to 1970. The figure for the sine is correct to four significant figures for the approximate period 1915 to 1965. For the preceding fifty years the value 0.3980 should be used for the sine.

Obtain P from the equation

$$P = a^{3/2}.$$

These equations have been set up for the position of the meteor at the time of fall, which may be either the ascending node or the descending node. The conventional notation is to count the longitude of the node and the longitude of perihelion from the ascending node. If the heliocentric radiant, or the geocentric radiant, of the meteor is south of the ecliptic, the meteor fell at the ascending node and the quantities as determined are those which should be given in the published orbit. If, however, the heliocentric radiant is north of the ecliptic, the meteor fell at the descending node of its orbit and the longitudes should be increased by 180°.

Hence, if the heliocentric radiant is south of the ecliptic,

$$\omega = \omega_1, \ \Omega = \Omega_1, \text{ and } i = i_1.$$

If the heliocentric radiant is north of the ecliptic,

$$\omega = \omega_1 + 180°, \text{ and } \Omega = \Omega_1 + 180°.$$

For a typical fireball, the heliocentric radiant is within some 15° of the ecliptic and within some 40° of the anti-apex. For such, the orbit is direct and the inclination small. If the meteor fell at the ascending node, $\sin i_1$ is positive, and i is equal to i_1. If the meteor fell at the descending node, $\sin i_1$ is negative, and i is equal to $-i_1$.

If the heliocentric radiant of a meteor is found to be near the apex, it must be moving in a retrograde orbit. $\sin i$ would be negative at the ascending node, and i is equal to 180° plus i_1. However we have found no retrograde orbits among those calculated to date for fireballs.

As a check on i_1, calculate it from the formula

$$\cos i_1 = (xr' - rx')/(\sqrt{p} \sin \Omega_1).$$

Having determined ω, Ω, and i, the elements of the orbit can be assembled.

University of Iowa, June 19, 1939.

Planet Notes for November, 1939

By R. S. ZUG

NOTE: Greenwich Civil Time is employed unless otherwise stated. To obtain Eastern Standard Time subtract 5 hours, Central Standard Time, 6 hours, etc. The planetary phenomena are described as they are to be seen from latitude 45° N. The data are taken chiefly from the *American Ephemeris and Nautical Almanac*.

Sun. The apparent positions of the sun for November 1 and November 30, respectively, are: $\alpha = 14^h\,21^m.2$, $\delta = -14°\,4'.2$; $\alpha = 16^h\,20^m.1$, $\delta = -21°\,27'.7$. On November 1 the sun is in the constellation Libra, through which it moves until November 23 when it enters the constellation Scorpio. On November 29 the sun enters Ophiuchus. Values for the equation of time are as follows:

Date 1939	Equation of Time (Mean - Apparent) m s	Date 1939	Equation of Time (Mean - Apparent) m s
Nov. 3	−16 23	Nov. 19	−14 49
7	−16 20	23	−13 53
11	−16 3	27	−12 43
15	−15 33	Dec. 1	−11 22

Moon. Phenomena of the moon will occur as follows:

		h	m
Last Quarter	Nov. 4	13	12
New Moon	11	7	54
First Quarter	18	23	21
Full Moon	26	21	54
Perigee	Nov. 7	21	
Apogee	19	19	

Mercury. Mercury will be an evening star during most of November. It reaches a greatest eastern elongation at 23° 10′ on November 8, at which time the stellar magnitude of the planet will be 0.0. The planet will be near the horizon at sunset, however, and therefore unobservable in the evening sky. Inferior conjunction with the sun occurs on November 28.

Venus. On November 1 this planet will be a bright evening star of stellar magnitude −3.4, situated about one hour east of the sun, and in approximately the same declination as the sun. Its situation for early evening observation will be improving, as its elongation from the sun is increasing. It should be possible to locate Venus at mid-day with the naked eye, by looking about 15° east of the sun, and to observe the planet then with telescopic aid. Tabular data are listed on p. 33 of the January (1939) issue of POPULAR ASTRONOMY.

Mars. Mars is still a conspicuous star. The stellar magnitude varies from −0.4 on November 1 to +0.2 on December 1. By December 1, the planet will have moved from the constellation Capricornus into Aquarius. Mars will be in eastern quadrature with the sun on November 29.

Jupiter. Jupiter will be situated about a degree and a half south of the vernal equinox in the constellation Pisces, during November. The planet retrogrades slowly until November 25, when the apparent motion again becomes direct. The stellar magnitude is −2.3.

Saturn. Saturn is to be found in the constellation Pisces during November. The stellar magnitude of the planet will be +0.3.

An occultation of an 8.5 magnitude star by Saturn is predicted for November 25, by Mr. Arthur Burnet, in his article, "Occultations by Planets," published in *The Handbook of the British Astronomical Association,* for 1939. The phenomenon will occur at a time favorable for observers in North and South America, and should prove an interesting sight. Details concerning the times of immersion and emersion, taken from Mr. Burnet's article, are given on p. 35 of the January (1939) issue of POPULAR ASTRONOMY.

Uranus. Uranus will be in opposition with the sun on November 13. The stellar magnitude of Uranus at opposition is +6.0. Apparent positions of the planet for November 1 and November 30, respectively, are:

$$\alpha = 3^h\,12^m.4,\ \delta = +17^\circ\,32'.9;\ \alpha = 3^h\,7^m.6,\ \delta = +17^\circ\,14'.1.$$

Neptune. Neptune is now observable in the morning sky, but rises only three hours before the sun. The apparent positions of the planet for November 1 and December 1, respectively, are:

$$\alpha = 11^h\,42^m.1,\ \delta = +3^\circ\,12'.4;\ \alpha = 11^h\,44^m.6,\ \delta = +2^\circ\,57'.7.$$

Asteroid Notes

By HUGH S. RICE

Three of the largest asteroids are available to observers with small telescopes during October and November. Ceres is not in a good position until December. Pallas is getting brighter but will not be in its best position until later in the winter. However, it can be located as follows: on October 3, at 6:00 P.M., C.S.T., it is about 3° northeast of Sirius, the magnitude being 7.9. From this position its apparent path takes it to a point approximately 2° southwest of ξ Puppis on November 24, and the magnitude then is 7.3.

Juno is still followed from our chart in the June-July issue of this magazine. The magnitude is 8.4 to 8.8 in October and November. Vesta's chart, appearing in the preceding issue, is still good for October. Opposition occurs on October 28, and the magnitude is 6.8 just before this.

The next brightest minor planets observable this autumn are 50 Virginia and 511 Davida, for which ephemerides follow. Our positions of all asteroids used have been computed by the Coppernicus Institut at Dahlem, Germany.

EPHEMERIDES OF ASTEROIDS. FOR 0^h U.T.

50 VIRGINIA ($9^M.6$)			511 DAVIDA ($8^M.7$)		
	α (h m)	δ (° ′)		α (h m)	δ (° ′)
Sept. 22	1 27.6	+ 7 29	Oct. 24	3 26.9	— 4 23
30	1 24.0	6 43	Nov. 1	3 21.3	4 47
Oct. 8	1 19.2	5 50	9	3 14.9	5 0
16	1 13.8	4 56	17	3 8.1	4 59
24	1 8.6	4 8	25	3 1.7	4 44
Nov. 1	1 4.5	+ 3 29	Dec. 3	2 56.0	— 4 14

Hayden Planetarium, American Museum of Natural History,
New York City, September 13, 1939.

Occultation Predictions

(Taken from the *American Ephemeris*)

Date 1939	Star	Mag.	IMMERSION Greenwich C.T. h m	IMMERSION a m	IMMERSION b m	IMMERSION Angle E from N °	EMERSION Greenwich C.T. h m	EMERSION a m	EMERSION b m	EMERSION Angle E from N °
Occultations Visible in Longitude +72° 30′, Latitude +42° 30′.										
Nov. 2	26 Gem	5.1	4 25.8	−0.7	+1.2	96	5 34.1	−1.1	+1.2	266
4	A^2 Cnc	5.7	10 20.8	−1.9	−0.1	98	11 37.9	−1.5	−1.6	305
15	ρ Sgr	4.0	22 21.3	..	..	134	23 0.9	..	..	193
18	c^1 Cap	5.3	20 47.3	..	..	350	21 6.4	..	..	326
18	c^2 Cap	6.2	20 51.9	−1.9	+1.2	80	22 17.6	−1.7	+1.3	232
24	54 Cet	5.9	6 1.2	−1.0	−0.6	73	7 10.9	−0.6	−1.0	258
28	119 Tau	4.7	7 20.0	−1.5	−1.6	115	8 32.0	−1.6	−0.4	253
28	120 Tau	5.5	8 8.1	−1.2	−2.1	123	9 13.3	−1.4	−0.4	248
30	λ Gem	3.6	1 13.4	0.0	+0.9	104	2 8.5	−0.2	+1.4	262
30	68 Gem	5.1	9 38.1	−1.0	−2.3	137	10 40.9	−1.5	−0.7	256
Occultations Visible in Longitude +91° 0′, Latitude +40° 0′.										
Nov. 2	26 Gem	5.1	4 15.9	−0.1	+1.3	88	5 15.9	−0.5	+1.1	272
4	A^1 Cnc	5.7	7 55.6	..	..	33	8 19.0	..	..	353
4	A^2 Cnc	5.7	9 48.9	−1.6	−0.3	118	11 7.4	−1.9	0.0	278
14	BD−19°5047	7.0	23 41.1	−1.4	−1.1	92	0 52.1	−0.6	−0.5	242
15	ρ Sgr	4.0	21 35.4	−2.6	−0.8	116	22 43.2	−1.4	+1.3	215
25	54 Cet	5.9	5 35.8	−1.7	−0.2	76	6 55.9	−1.3	−0.3	248
28	119 Tau	4.7	6 49.6	−2.1	−1.9	129	7 55.8	−2.1	+1.6	232
28	120 Tau	5.5	7 46.8	−1.7	−3.5	145	8 38.1	−2.3	+2.3	221
29	26 Gem	5.1	12 57.6	−0.5	−1.1	87	13 53.8	+0.1	−1.7	297
30	68 Gem	5.1	9 31.1	..	..	178	9 55.6	..	..	212
Occultations Visible in Longitude +120° 0′, Latitude +36° 0′.										
Nov. 4	A^1 Cnc	5.7	7 40.9	..	..	31	8 1.3	..	..	348
4	A^2 Cnc	5.7	9 16.2	−0.8	−0.4	132	10 14.6	−1.0	+1.8	253
4	60 Cnc	5.7	14 31.8	−2.3	−0.2	88	15 44.4	−1.2	−2.4	319
17	16 B.Cap	6.2	2 47.8	−1.8	−0.8	89	4 1.6	−0.7	+0.4	226
17	β Cap	3.2	2 58.0	−1.8	−1.0	94	4 8.5	−0.6	+0.6	222
18	ν Aqr	4.5	3 58.9	..	..	3	4 36.1	..	..	306
24	54 Cet	5.9	4 35.0	−1.8	+1.8	56	6 3.2	−2.2	+0.6	254
28	119 Tau	4.7	5 53.8	−1.8	−0.5	124	6 52.0	−1.2	+2.8	224
28	120 Tau	5.5	6 54.8	..	..	157	7 20.8	..	..	194
29	26 Gem	5.1	12 40.9	−1.0	−2.2	130	13 45.1	−1.3	−0.7	257

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

The writer was on vacation for the latter part of August and early September and, since returning, it has been impossible in the press of other work to examine properly as yet, much less tabulate, the results of the observations reported on the Perseids. If, as usual, some of our groups wait several weeks to send in their results, probably only part of the data has arrived. In a later issue the usual summary and discussion will be attempted, and I will content myself here with requesting our members not to delay unduly reports on the work of the summer.

Several unusual fireballs, which left long-enduring trains and three from which meteorites have already been found and identified, came during the summer months. The places of fall were Canada, Oregon, and Texas. It is quite possible that accounts of others have so far escaped me, due to my rather long absence. The A.M.S. deals only incidentally with meteorites, but we are vitally interested in all fireball phenomena, and, as so often said, we are most desirous of securing all the data anyone has on long-enduring trains. As many persons certainly saw the remarkable trains of the objects mentioned, and have doubtless neglected to report, they are urgently requested to write us and describe what was seen. The number of minutes the train remained visible and the direction in which it or its parts drifted, as well as changes of shape it underwent, are things we should like to know in every case. Copies of photographs taken of the trains would be most gratefully received. Incidentally, several such have been taken this year.

On October 9, 1940, we should normally expect a return of the rich Draconid shower seen in 1933. But as the period of the accompanying comet, Giacobini-Zinner, is 6.60 years and it last passed perihelion on 1933 July 15, there is a good chance that we may get a shower from this group in 1939. I strongly advise everyone to keep at least a casual watch on the three nights of October 8, 9, and 10, as meteors are erratic and a day's variation from the predicted date might be expected. In 1933, the shower was seen in Europe in the early hours of the night, but it was over before it became dark in America. This proves that it took the earth only a few hours to pass through it and hence, assuming a central passage, the stream is a relatively narrow one—or was so in 1933. Again, sad experience shows that a stream may be badly dispersed by planetary perturbations, so the fact that a stream was compact six years ago is no proof that it still is. However, if it does show up this year, it would be a great misfortune for it to be missed, due to carelessness. Also, as a general proposition, our colleagues in Europe will be unable to carry on their astronomical work effectively, if at all, so it becomes our duty more than ever to make the most of our good fortune in still being able to continue our normal work. If history repeats itself, meteoric astronomy will almost die out in Europe as during the period 1914-1920, and, once we entered the war ourselves, little was done in America then and for many years afterwards.

The Orionid meteors are visible during the second half of October; observations could begin with profit on October 17 and run through the next ten days. The maximum used to be very definitely on October 19-20, but of late years it has often been delayed two or three days. As this stream has the greatest theoretical as well as practical importance, I request our A.M.S. observers to make plans for

real observations on several dates in this interval. Heights for these meteors are badly needed. In states where we have many observers, cannot two groups be organized and placed 30 to 60 miles apart for simultaneous observations? In all frankness, it is time that our members did more plotting, and did not content themselves with merely counting for an hour or two at a time, as so many do. We need to develop men who are really excellent observers and whose work can be used to determine accurate radiants, and heights when done simultanously. Such observers are not developed by going out for an hour, two or three times per year. Maps and instructions should be in the hands of everyone; more will be sent on application. The moon will not interfere much with the Orionids, if observations start as they should about midnight. Will not our A.M.S. members everywhere really get busy and make a concerted effort to carry to success a fine campaign on the Orionids of 1939? If only one full night can be devoted to this, I suggest the second half of either October 19-20, 20-21, or 21-22. Meteors should be seen at the rate of at least 15 per hour on all of them, after the moon has set.

People often write asking about the Bielids of late November. This stream seems to have practically ceased to exist, and there is little hope of the Bielids reappearing in future as a strong shower. It furnishes the classical example of the dispersion of a well-known meteor stream. The Leonids are now well past their theoretical maximum for 1933±. However, their great importance requires that regular observations should not be neglected in any November, so that a more nearly complete picture of the whole stream may be had, even if their hourly numbers are now likely to be somewhat low. But in 1938 on one night at least, an unexpectedly rich shower appeared, well worth seeing. I suggest observations on the three nights of November 14-15, 15-16, and 16-17, and hope that every one of our observers will manage to observe on at least one of these nights—and for several hours in a stretch while they are about it! It is only by keeping up observations for several hours and plotting that one ever attains real proficiency or even gets a full picture of the meteoric activity on a given night.

As our supply of the older edition of meteor maps has already given out for certain of the 13 numbers used in the northern hemisphere, the new, corrected edition ably prepared by our colleague E. A. Halbach of Milwaukee, is now being supplied in these numbers and soon will be for all when the older maps are distributed. Observers will find these newer maps more convenient as well as more nearly accurate, and with more stars to be used as comparsion points.

1939 September 13, Flower Observatory, Upper Darby, Pennsylvania.

Meteors observed in California

The display was witnessed by myself and assistant just as we left the dome for the campus. We had been engaged in a long exposure of the region midway between Aquila and Ophiuchus and had noticed numerous small shooting stars, none of which had crossed the field.

Promptly at 12:20, six were seen in rapid succession, seemingly emanating from the region from Delphinus to Pegasus, and extending southwest to Sagittarius, the shortest traversing a distance of approximately five degrees, and the longest from twenty-five to thirty degrees. It is interesting to note the fact that all fell toward the horizon. All started from a point high in the sky, and descended rapidly in a southwest direction, extinguishing themselves almost immediately. Twenty-six fell in a period of approximately five minutes, the period of activity ceasing at or before 12:26 on the morning of August 14, 1939.

On the evening of August 14, directly overhead, extending from Ursa Major to Aquarius, a most magnificent meteor was observed, leaving a distinctly yellow train which vanished in 30 seconds. The ball was yellowish green, and burst at the close of the fall with a dull distant detonation which was heard approximately 25 seconds from the time when all traces had vanished. During the evening we were careful to notice that all the shooting stars which we observed traveled from north to south predominantly, and closely followed the parallel of the horizon. This was entirely different from those which were seen so very early that morning. The ones of the evening of August 14 came from no specific place, but were characterized by the flight from north to south, closely paralleling the horizon in the majority of cases.

HERMAS I. SMITH, Photographer.

Newton Observatory, Angwin, California, August 14, 1939.

Contributions of the Society for Research on Meteorites

Edited by FREDERICK C. LEONARD,
Department of Astronomy, University of California, Los Angeles

President of the Society: H. H. NININGER, Colorado Museum of Natural History and American Meteorite Laboratory, Denver

Secretary of the Society: ROBERT W. WEBB, Department of Geology, University of California, Los Angeles

Meteorite Falls and Bright Fireballs Observed in Sweden in the Last Twenty Years

By AXEL CORLIN,
Observatory, Lund, Sweden

ABSTRACT

In this paper are briefly described: (1) the meteorite of 1922 February 12, which was observed to fall into a small frozen lake at Skåne-Tranås but which has never been recovered; (2) the 3½-kg. aërolite, observed to fall on 1922 April 20, at Hedeskoga, Skåne (photograph); (3) the meteor of 1936 September 22, unrecovered fragments from which may have fallen into the forests around Loos in central Sweden; (4) the remarkable swarm of fireballs of 1938 May 27, which were observed over a large part of southern Sweden but from which no meteorites have been found; (5) the 3.3-kg. aërolite and a small fragment which separated from it in flight, observed to fall on 1939 April 5, at Ekeby in western Skåne (photograph); and (6) the fireball of 1939 May 26, which also was extensively observed from southern Sweden but which has as yet yielded no meteorites.

A recent meteorite fall in southern Sweden, which will be briefly described hereafter, has drawn my attention to the possibility that some earlier meteorite falls and bright fireballs which have been observed in Sweden, may have escaped notice in the CONTRIBUTIONS OF THE SOCIETY FOR RESEARCH ON METEORITES. As the recording of such phenomena by this Society is most valuable for meteoritical statistics, a short report of those phenomena which have been observed in Sweden in the course of the last twenty years, may be of interest. It may be added that the few known, still earlier, meteorite falls in this country all occurred in the twentieth century.

(1) On 1922 February 12, a meteorite fell at Skåne-Tranås, a little place 20 km. W.N.W. of the town of Simrishamn on the eastern coast of Skåne (Scania), the southernmost tip of Sweden. This fall was accompanied by a loud noise, heard for three minutes, and people saw the meteorite fall into a little frozen lake. Here an elliptical hole, 18 × 20 cm., surrounded by black, microscopic dust particles, was immediately found on the ice. Later on, the lake was drained, and the bottom was thoroughly investigated by Professor Assar Hadding of the Geological Institute of Lund, but no meteorite was found. Perhaps it had been wholly destroyed by the water.

(2) On 1922 April 20, another meteorite fell in Skåne, namely at Hedeskoga, 3 km. N.W. of the town of Ystad on the southern coast, and this meteorite was picked up and thoroughly investigated. The meteorite fell with a loud noise, very near a farmhouse, at about $18^h\,45^m$ G.M.T. The farmer's family could not see any trace of the meteorite in the dusk of the evening, but next morning they saw a hole in the hard ground, about 12 cm. deep and a meter in front of the door of their barn, and they picked up the meteorite, which was sent to, and is still kept at, the

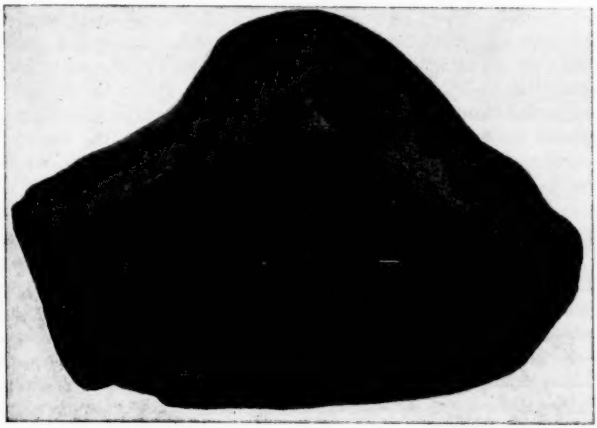

FIGURE 1
THE HEDESKOGA, SKÅNE, SWEDEN, AËROLITE OF 1922
(Half Size)

Geological Institute of Lund. Some 10 observations of the meteor arrived from different parts of southern Sweden and proved that the meteorite moved from N.W. to S.E. and became extinguished before it reached the ground. No explosion occurred.

The stone, which weighed 3.515 kg., showed no fractures, but some clear traces of a rotational motion. It was a typical gray chondrite, with chondri up to 2 mm., consisting mostly of olivine, some troilite, and nickeliferous iron. It measured 9 × 12 × 17 cm. and had a specific gravity of 3.17. It is reproduced in Fig. 1, and has been exhaustively described by Professor Hadding in *Geologiska Föreningens i Stockholm Förhandlingar*, **46**, May, 1924.

(3) After the year 1922, no meteoritic fall in Sweden was reported, as far

as I know, until 1936 September. On the evening of 1936 September 22, a very bright meteor, exploding with far-audible thunder, was observed over a large part of central and northern Sweden. The instant of the explosion was $17^h\,21^m5$ G.M.T., and some 130 observations arrived as a consequence of a broadcast request. The observational material was treated by Dr. E. Johansson of the Observatory of Upsala, who also calculated the orbit and the space velocity of the meteorite. The coördinates of the true heliocentric radiant point were, according to him, $\alpha = 289°$, $\delta = -14°$; the heliocentric velocity was 41 km./sec., and the orbit had the elements, $\Omega = +180°$, $\pi = +37°$, $q = 0.90$, and $i = +8°$. The explosion occurred at a height of 20 ± 3 km. above the ground, and the fragments fell probably into the forests around Loos in central Sweden, at long. 2° 40′ west of Stockholm, lat. +61° 40′, but no fragments have as yet been picked up. The fireball and the observations have been described by Dr. Johansson in *Festskrift tillägnad Östen Bergstrand*, Upsala, 1938 (in German), and in *Populär Astronomisk Tidskrift*, **18**, 93, 1937 (in Swedish).

(4) On 1938 May 27, between 18^h and 20^h G.M.T., probably a whole swarm of bright fireballs was observed over a large part of southern Sweden; the fireballs that were observed most were seen at $18^h\,40^m$ G.M.T. Thanks to requests in the newspapers, not less than 550 observations were collected, and this material has been treated by the author. In addition, some 6 other fireballs or bright meteors were reported on the days immediately preceding and following May 27. As this swarm of fireballs and some results of the investigation of it have been preliminarily reported by the author in a special communication to the Society for Research on Meteorites, to appear elsewhere in POPULAR ASTRONOMY, we shall here only refer to that communication.

(5) On 1939 April 5, at $6^h\,12^m$ G.M.T., a meteorite fell in a field near the railroad track at Ekeby in western Skåne. Some railroad workers were present at the spot, saw a little smoke from the hole, and immediately picked up the meteorite, which had penetrated only 35 cm. into loose ground. A few hours later, members of the staff of the Geological Institute of Lund were present at the place of fall. Nobody seems to have noticed the accompanying *meteor*, in the broad daylight of the morning sky—there was also some fog—but many persons heard the loud noise at distances of at least 13 km. from the place of fall. This noise was heard for two full minutes, as was noted by an observer who read his watch just as soon as the sound became audible; accordingly, the velocity of the meteorite must have been considerably less than that of sound. The noise was like that of a starting motorcycle or a machine-gun, and ceased when the meteorite reached the ground, but a short hissing noise also was heard afterwards by the railroad men and was correctly ascribed to a fragment, which split off from the main mass at the last moment of flight and was later found 8 m. from the hole made by the parent meteorite.

The principal mass has the form of a triangular prism, $14 \times 14 \times 7$ cm., and weighs 3.31 kg. (*v.* Fig. 2). It is a typical chondrite, consisting of olivine. The mineralogical composition has not been fully investigated as yet, but a study of this will be made by Professor A. Hadding, who intends to publish an exhaustive description of the aërolite elsewhere. Most interesting is the fact that the meteorite shows the effects of not less than seven distinct fractures of different ages due to its passage through the atmosphere. It is easy to follow the decreasing degree of corrosion of the fractured surfaces, and the last fractured surface is very fresh and just fits the previously mentioned fragment, found at a distance of 8 m.!

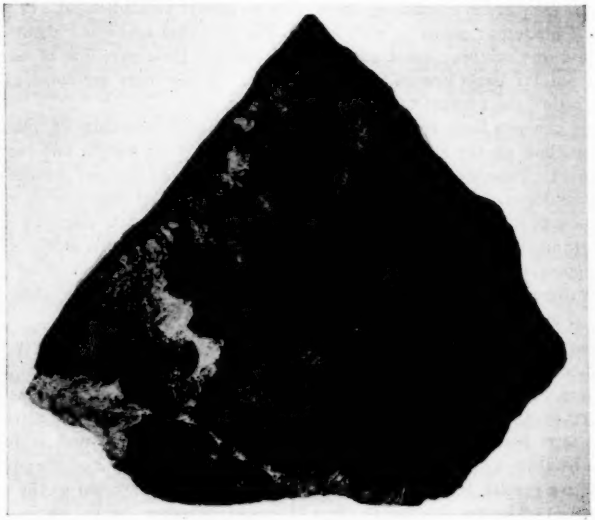

FIGURE 2
THE EKEBY, SKÅNE, SWEDEN, AËROLITE OF 1939
(About Half Size)

(6) On the evening of 1939 May 26, a bright fireball was again observed from a large part of southern Sweden; nearly a hundred observations of this have already arrived at the Observatory of Lund. The observational material has not been treated sufficiently as yet to permit of definite conclusions concerning the direction and the point at which the meteorite may have fallen. It is interesting to note, however, that this fireball was observed almost exactly one year after the fireball swarm of 1938 May 27, and at the same spot on the earth's surface; hence, our planet had twice moved through nearly the same point on its orbit in the interim, and this fireball may have had the same direction in space as did the swarm of a year ago!

The Occurrence of Platinum in Meteorites

By F. G. HAWLEY,
Chief Chemist, International Smelting and Refining Company,
Miami, Arizona

ABSTRACT

In the course of the past twenty years, the writer has made a special study of the platinum content of meteorites. Practically complete analyses, including platinum, have been made of 29 falls, comprising 19 siderites, 9 aërolites, and one pallasite (siderolite). An extremely interesting fact brought out by these analyses is that platinum was present in every instance. Possibly of even more interest is the fact that the meteorites with high nickel content were found to contain much more platinum than those with low nickel content. Following are some representa-

tive assays: siderites containing about 16% of nickel yielded about 119 parts per million of platinum; siderites with 6% to 8% of nickel contained about 14 parts per million of platinum; while aërolites containing a little over 1% of nickel contained about 1.7 parts per million of platinum. While there are some exceptions to these ratios, the general uniformity is striking.

Many analysts have reported the presence of small amounts of platinum in meteorites, but, on the other hand, it has sometimes been sought and reported as being absent. Possibly the reason for this fact is that the amount present was too small to be detected by the method used. The detection of platinum in extremely small amounts is a difficult and uncommon procedure, and few chemists have had an opportunity to gain the experience and skill necessary for this work. This fact can be appreciated readily when it is stated that the average amount of platinum found in these 29 falls amounts to only about 0.002%, which is less than the percentage of any other element determined.

When *platinum* is mentioned in this article, the word is used collectively to include other metals of the platinum group, as iridium, rhodium, palladium, and perhaps others. The quantitative separation of minute quantities of these metals presents very great difficulties; therefore it was not attempted. Qualitative microchemical tests for iridium were made on many of the samples, and iridium was found to be always present. Tests for palladium were made on 2 of the meteorites, with positive results. It may be that spectroscopic analysis, applied to the platinum metals obtained by the fire assay, would prove whether other platinum-group metals were present.

It is generally believed that all normal meteorites contain nickel and cobalt, and that the presence of these metals will help serve, in doubtful cases, to identify a meteorite. To these metals the writer would add platinum, which is apparently always present in meteorites in very small amounts.

It is interesting to note that the close association of the platinum metals with iron, nickel, and cobalt in meteorites—and also in some terrestrial deposits—is paralleled by their close association in the periodic table of the chemical elements; here all of these elements occur grouped in a solid block.

The method used by the writer for determining the presence of platinum in iron meteorites is a modification of the usual "fire" method. As the large amount of iron and nickel present would interfere, this is removed at the start by dissolving it in dilute sulfuric acid to which has been added 0.2 g. of copper sulfate. Copper precipitates on the iron and prevents loss of platinum. After the iron and nickel are dissolved, more copper sulfate is added, together with a little silver nitrate; the solution is saturated with hydrogen sulfide and later filtered. The filter paper is ignited, and the residue containing the platinum metals and silver is assayed by the fire method, using all the usual precautions. After cupeling the lead button, the bead containing the silver and platinum metals is parted by two treatments with 85% sulfuric acid, at a temperature of from 300° to 330° C. The residue of platinum metals is washed, dried, ignited gently, and weighed on a delicate gold balance. Most of the precautions needed in this work will be found described in *Technical Paper No. 270, U. S. Bureau of Mines*, entitled, "The Detection and Estimation of Platinum in Ores," by C. W. Davis.

The writer has been much interested in the composition of meteorites since 1901, when he made his first analysis of one while a student in the University of Arizona. In the course of the past twenty years, he has made a special study of

their platinum content. The chemical laboratory under his charge provides good facilities for the work. Dr. H. H. Nininger of the Colorado Museum of Natural History has provided many samples of meteorites for analysis, Dr. G. M. Butler of the University of Arizona has kindly furnished several, and a few have been obtained from miscellaneous sources. Practically complete analyses, including platinum, have been made of 29 falls, comprising 19 siderites, 9 aërolites, and one pallasite (siderolite). An extremely interesting fact brought out by these analyses is that platinum was present in every instance. Possibly of even more interest is the fact that the meteorites with high nickel content were found to contain much more platinum than those with low nickel content. Siderites with a nickel content of about 16% assayed about 3½ ounces per ton of platinum, which is equal to 0.0119%, or 119 parts per million. Siderites with 6% to 8% of nickel content yielded only about one-eighth as much platinum, or 0.4 ounce per ton. Aërolites that contained a little over one per cent of nickel averaged 0.04 to 0.06 ounce per ton of platinum, or 1.7 parts per million. While there are some exceptions to these ratios, the general uniformity is striking.

Many analysts have reported the presence of platinum in meteorites, but, as far as is known to the writer, none has claimed that it is universally present, and several very competent chemists have reported that some of the meteorites which they investigated contained *no* platinum. It is possible that there was really no platinum in these falls, but it seems more probable that a trace, too small to be detected by the method used, was present. The detection of extremely small amounts of platinum is a rather difficult and uncommon procedure, and few chemists have had an opportunity to gain the experience and skill necessary for this work. Spectroscopic analysis might be the best method to use in detecting the presence of small quantities of platinum, but the writer, who has had no experience in such work, understands that the spectral lines characteristic of platinum are more or less obscured by those of other metals, such as nickel.[1]

Lest anyone suspect that the writer is one of those optimistic chemists who always finds whatever rare element he seeks, it can be said that in the course of the past twenty-five or thirty years, he has assayed many—possibly over 200—samples of terrestrial rocks and gravels from the Southwest for platinum and has found it only a very few times and then mostly in traces.

When *platinum* is mentioned in this article, the word is used collectively to include other metals of the platinum group such as iridium, rhodium, palladium, and perhaps others. At best the separation and determination of the metals of this group are laborious and difficult matters and require larger samples than are usually available. Qualitative micro-chemical tests for iridium have been made on many of the samples, and a little was found to be always present. Quantitative determinations on 3 of them gave amounts equaling 20% to 30% of the amount of the platinum. Two qualitative tests for palladium gave positive results.

Mr. J. L. Howe, who analyzed the Canyon Diablo, Arizona, meteorite, found platinum-group metals as follows:

Pt: 11.2 parts per million;
Ir: 5.8 parts per million;
Pd: 2.1 parts per million.[2]

Davidson found in the Coahuila, Mexico, siderite:

Pt: 39.0 parts per million;
Ir: 2.44 parts per million.[3]

G. P. Merrill, who investigated the occurrence of platinum in meteorites, states

that it is commonly present in traces, with ruthenium and iridium less common.[4]

Possibly the only reason why the remaining metals of this group have not been found in meteorites is that it is extremely difficult to detect minute traces of them. It is probable that spectroscopic analysis applied to the small amount of platinum metals separated from the other elements by fire assay would yield valuable information. Following is a list of the meteorites assayed by the writer for platinum. The nickel is reported in percentages and platinum metals in parts per million.

		Nickel %	Platinum p.p.m.
	Siderites		
1.	Weaver Mountain, Arizona	16.63	142.0
2.	Tlacotepec, Mexico	16.23	138.2
3.	Piñon, New Mexico	16.32	86.4
4.	Monahans, Texas	10.88	26.1
5.	Duchesne, Utah	9.40	11.0
6.	Hualpai, Arizona	9.12	13.4
7.	Leeds, Quebec, Canada	8.27	9.6
8.	Xiquipilco, Mexico	8.15	14.7
9.	Ogallala, Nebraska	7.93	13.7
10.	Huizopa, Chihuahua, Mexico	7.90	9.6
11.	Coahuila, Mexico	7.85	12.0
12.	Tlaxcala, Mexico	7.39	12.3
13.	Chihuahua, Mexico	6.95	9.6
14.	Arispe (No. 7, year 1938), Sonora, Mexico	6.80	15.8
15.	Canyon Diablo, Arizona	6.58	9.6
16.	Ballinger, Texas	6.54	6.9
17.	Sandia Mountains, New Mexico	5.75	25.0
18.	Canyon Diablo, Arizona (oxidized shell)	4.58	8.6
19.	Canyon Diablo, Arizona (oxidized shell)	4.55	9.2
	Pallasite (Siderolite)		
20.	Springwater, Saskatchewan, Canada (metallic portion)	10.72	13.0
	Aërolites		
21.	Farley, New Mexico	1.52	1.7
22.	Hugoton, Kansas	1.27	1.0
23.	Plainview, Texas	1.26	2.4
24.	Moorland, Kansas	1.21	9.6
25.	Garnett, Kansas	1.16	2.0
26.	Roy, New Mexico	1.00	1.7
27.	Melrose, New Mexico	0.97	4.1
28.	Winslow, Arizona	0.96	1.0
29.	Arriba, Colorado	0.58	1.0

The preceding analyses seem to support the theory that all or nearly all normal meteorites contain some platinum and that the amount is more or less proportional to the nickel. There are a few exceptions; a few of the meteorites with low or moderate amounts of nickel contain considerable platinum. Possibly this fact can be explained as due to the difficulty of getting a representative sample because of the well-known tendency for the minerals of meteorites to segregate. More data on the platinum content of meteorites, especially those containing much nickel, would be very welcome, but such meteorites are rare and difficult to obtain.

Thirty-eight years ago, when the writer analyzed the Weaver Mountain, Arizona, meteorite, he was thrilled to find that it contained much more nickel than the average. At that time it was not suspected that platinum might be present; so it was not sought. When the association of platinum with nickel seemed to be established, Dean G. M. Butler of the University of Arizona was requested to furnish another sample of this siderite for a platinum assay. He kindly did so, and

the result entirely justified expectations, for the platinum content proved to be a little higher than that of any other meteorite analyzed.

When it is remembered that platinum and nickel are associated on the earth in the mines at Sudbury, Ontario, Canada, and in South Africa, it should not cause much surprise to find them closely associated in meteorites. The terrestrial deposits occur usually in or near basic igneous rocks and contain ordinarily more or less copper, cobalt, and chromium. All of the meteorites that the writer has analyzed also contain small amounts of these elements. Meteorites that contain much nickel contain usually more than the average amount of cobalt, but in general the relationship is not marked. The same thing can be said for copper, which runs usually between 0.03% and 0.12%.

While seeking for support for the theory that platinum is a practically constant associate of nickel, a few nodules of josephinite were analyzed and found to contain 0.12 ounce of platinum metals per ton. This natural alloy of nickel and iron, found in Oregon, was the only terrestrial alloy of these metals that could be secured.

Anyone who seeks an explanation of the close association of the platinum group of metals with nickel and cobalt will note with interest the position of these metals in the periodic table of the chemical elements, arranged in the order of their atomic weights. Here it is found that the 9 elements Fe, Co, Ni,—Ru, Rh, Pd,—Os, Ir, Pt, occur as a solid block or group. The first 3 occur in sequence on the third line; the next 3 occur immediately below the first 3, and directly below them are the last 3. Pt and Pd are in the same vertical line with Ni. This close periodic association is certainly more than a coincidence.

Stony meteorites resemble ordinary basic rocks so closely that assaying them for platinum metals presents no unusual problems. A good description and discussion of the standard methods and a comprehensive bibliography on the subject are found in *Technical Paper No. 270, U. S. Bureau of Mines*, entitled, "The Detection and Estimation of Platinum in Ores," by C. W. Davis. When analyzing an aërolite, the coarser metallic particles were first removed by screening on an 80-mesh sieve, and the proportion of Pt in the fines alone was determined. These fines did contain, however, very small particles of metallics and all of the original metallics that had been oxidized. The coarse metallics were analyzed for Fe, Ni, Co, and Cu, but there was, unfortunately, never enough of them for a Pt assay. If the coarser metallics contained a larger proportion of Pt than the fine, largely non-metallic material, as is very probable, then the amount of Pt reported for the aërolites is somewhat too low. This error is probably extremely small, however.

The problem of analyzing siderites is more complicated; the large proportion of metallic iron and nickel will, unless removed, interfere badly with the fire assay. The method used by the writer has proved very satisfactory, and, since some of the details may be new, the following short description is given.

Place 20 to 30 g., or even more, of the sample, preferably as drillings or "saw dust," in a large beaker, with about 0.2 g. of copper sulfate and a little water. Add enough 15% H_2SO_4 to dissolve the sample, usually 200 to 400 ml., and then heat. The iron dissolves slowly; the platinum, of course, does not, but the particles are so tiny that it can be lost later, while filtering, if special precautions are not taken. Metallic copper precipitates on the dissolving iron and partly envelopes and holds the platinum. As an extra precaution, add 0.2 g. more of copper sulfate; add also 8 or 10 parts of silver for each part of platinum judged to be present; the silver can be added as $AgNO_3$. Pass H_2S through the solution until it is saturated, and

let it stand for an hour. The precipitated copper sulfide collects any platinum that escapes the metallic copper. Add 2 or 3 ml. of saturated solution of lead acetate, stir a short time to coagulate the precipitated lead sulfate, then let the material stand for several hours. Filter the solution through a close filter paper into which have been put 4 or 5 g. of ground glass. Dry the filter and ignite it in a scorifier or a crucible, add the proper flux, and assay by the regular fire method, using a little more heat than for gold assays. Cupel the lead button that contains the platinum metals and the added silver on a magnesite cupel at a temperature of about 850° C. Remove the bead, brush it lightly, and then clean more thoroughly by boiling it with a little 20% HCl. Put the bead into a small porcelain crucible covered with a watch glass and heat nearly to the boiling point with 80% or 85% H_2SO_4. Watch the bead carefully, raising the temperature slowly until bubbles of sulfur-dioxide gas appear; hold at this temperature until bubbling ceases; then heat still hotter (to about 330° C.) and keep very hot for 20 minutes or so. Cool partly and carefully decant off most of the acid. Add fresh H_2SO_4 and repeat the treatment to make certain that all the Ag and any trace of retained Pb are dissolved. Cool and wash, first with hot 50% H_2SO_4, then with hot water, and finally with alcohol. Slow parting, long settling, and careful washing are necessary to prevent loss. After drying, anneal slowly. If any platinum adheres to the crucible, loosen it with a needle point. Cool and weigh on a sensitive gold balance. The residue can be tested for iridium by treating it with *aqua regia;* the undissolved residue will be mostly Ir.

To prove that Pt was really present, a qualitative test can be made as follows: Evaporate the solution down to 2 or 3 drops; then dilute to 1 or 2 ml. and add a few drops of a solution of stannous chloride, which imparts a yellowish- to brownish-red color, depending upon the amount of Pt present.

REFERENCES

[1] A. S. King, *C.S.R.M.: P. A.*, **44**, 509; **1**, No. 2, 49, 1936.
[2] *Sci., N.S.*, **66**, 220, 1927.
[3] *Am. Jour. Sci.*, **7**, No. 4, 4, 1899.
[4] *U. S. Nat. Mus. Bull.* No. 149, 8, 1930.

Representative Appointed for the Sixth Pacific Science Congress

Professor Earle G. Linsley, Director of the Chabot Observatory and Professor of Astronomy at Mills College, Oakland, California, was appointed by the Executive Committee of the Council to serve as the Representative of the Society at the Sixth Pacific Science Congress of the Pacific Science Association, held at Berkeley, Stanford University, and San Francisco, California, July 24 to August 12, 1939, under the auspices of the National Research Council of the United States of America, of Washington, D. C.

Comet Notes

By G. VAN BIESBROECK

COMET 1939 *h* (RIGOLLET). A fairly bright unexpected comet was discovered on July 28 by the French variable-star observer Roger Rigollet. The first announcement through the Bureau of the International Union in Copenhagen gave the following data:

1939 July 28.0868 U.T. R.A. $4^h\,54^m0$. Decl. $+25°\,45'$.
Magnitude 8. Nucleus but no tail.
Daily motion four degrees northeast.

The comet was first visible only in the early morning. The discovery was immediately confirmed in several observatories and by August 1 very similar preliminary orbits were published by several computers, as follows:

	Kaster-Bartlett Berkeley, Calif.	Maxwell Ann Arbor, Mich.	Möller Copenhagen
T	1939 Aug. 9.198	Aug. 9.117	Aug. 9.070
ω	28° 53′	28° 42′	28° 37′
Ω	355 19	355 17	355 3
i	63 56	63 55	63 37
q	0.7499	0.7503	0.7499

These indicated that the comet was approaching its point nearest to the sun and that its distance from the earth was smallest at the time of discovery. On the basis of the above elements, L. E. Cunningham found that this comet is probably identical with COMET 1788 II, discovered by Caroline Herschel at Slough, England, on December 21, 1788. The best parabolic elements given by Miss M. Palmer from a discussion of the rather crude observational material which extended to 1789 February 4 are:

T	1788 Nov. 20.368	
ω	30° 26′	1939
Ω	354 35	
i	64 29	
q	0.7574	

The analogy is striking and makes it probable that this comet has a period of 151 years. A more nearly accurate orbit has now been computed by A. D. Maxwell and Mrs. K. P. Kaster assuming a period of 150 years and using three Lick observations on the dates: July 29, August 4, and August 15. These elements are:

T	1939 Aug. 9.46490 U.T.	
ω	29° 17′ 53″.4	1939.0
Ω	355 7 17.6	
i	64 11 58.7	
q	0.748459	
e	0.973498 (per. 150 years)	

The following ephemeris is based on these elements:

1939	α h m	δ ° ′	Distance from earth	Distance from sun
Sept. 26	11 53.8	+42 36	1.66	1.16
Sept. 30	12 3.9	41 10	1.72	1.22
Oct. 4	12 12.8	39 49	1.78	1.27
Oct. 8	12 20.9	38 33	1.83	1.32
Oct. 12	12 28.2	37 23	1.89	1.38

Accordingly the comet will during these days move slowly through the constellations of Ursa Major and Canes Venatici but remains unfavorably situated nearly in conjunction with the sun. At present it can be observed almost as well in the evening twilight as in early dawn but it is always at low altitude. In October the conditions become better in the morning sky. During the month of August the writer estimated the total brightness up to $7^{M}.3$ (Aug. 5). When the moon was out of the way, an exposure of 20 minutes with the 24-inch reflector showed (Aug. 15) a coma of 3′ in diameter with a sharp central nucleus and a slender threadlike tail visible over a length of one degree in the direction away from the sun. The increasing distance now reduces the intensity and soon the comet will become difficult to see in small instruments.

On July 31, three days after the announcement of COMET 1939 *h*, another cablegram from Copenhagen informed observatories of the discovery of a comet of seventh magnitude at Tashkent (Siberia) by Kaminsky. The rough positions,

1939 July 24	$22^h\ 0^m$ U.T.	$20^h\ 55^m.0$	$-7°\ 00'$
July 28	22 53	21 17.5	−18 23,

seem to be deduced from photographic plates and indicate a rapid southerly motion. One additional position, August 1, $0^h\ 51^m.8$ U.T., $21^h\ 30^m.4$, $-27°\ 54'$, obtained photographically by Fresa at Turin (Italy) apparently confirms the find. On the other hand the writer was unable to locate any object as bright as 7^M in the region indicated. It is true that the bright moonlight interfered but objects as faint as 11^M were visible in the region explored. Much stronger negative evidence was given by the Harvard College Observatory where a plate exposed on July 21 to the region of the comet and showing stars down to magnitude 13.5 had no indication of the presence of an object of the description given by Kaminsky. No further information has become available about this questionable object which will therefore not receive any provisional designation.

On August 14 the Harvard College Observatory announced the expected recovery of PERIODIC COMET TUTTLE. The observation was made at the Lick Observatory by H. M. Jeffers who has recently been very successful in photographing extremely faint comets with the 36-inch Crossley reflector. The first data are the following:

1939 Aug. 12 $11^h\ 20^m.2$ U.T. R.A. $5^h\ 55^m.8$ Decl. $+57°\ 22'$
Magnitude 18. Nucleus. No tail.

They indicate that the ephemeris given by A. C. D. Crommelin in the *Handbook of the British Astronomical Association* is quite accurate and requires only an advance of 0.7 day in the time of perihelion passage. The comet was situated in Auriga when first observed and will remain a morning object as is indicated by the following ephemeris:

EPHEMERIS OF COMET 1939 *i* (TUTTLE)

1939	α (1950)	δ (1950)
	h m	° ′
Sept. 30	8 52.7	+33 51
Oct. 8	9 14.8	26 37
16	9 35.8	18 12
24	9 56.8	+ 8 33
Nov. 1	10 17.9	− 2 4

Maximum brightness is expected about the time of perihelion passage (Nov. 11) but it is not probable that the comet will come in reach of small telescopes. This is the seventh return of this comet since it was discovered in 1790 by the French astronomer Méchain. It was not reobserved until it was found independently by Tuttle at the Harvard College Observatory in 1858. Since then it has been followed at each successive return indicating a period of 13.6 years.

The only previously announced comets still under observation are PERIODIC COMET 1939 *e* (KOPFF) and COMET 1939 *g* (BROOKS II). Both are well situated but can only be reached by powerful telescopes. On September 9 the writer estimated their magnitudes as 15 and 13.5, respectively. The expected Wolf's second periodic comet has not yet been recovered. It is a morning object but its location is very uncertain. It comes to perihelion next December.

Williams Bay, Wisconsin, September 11, 1939.

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

Bright Maximum of Z Andromedae: A marked increase in the light of the nova-like variable, Z Andromedae, 232848, has occurred in recent months. From a minimum magnitude of 10.7 in April, 1939, the star has steadily become brighter, until magnitude 8.6 was attained on August 21, and with the possibility that it may increase still more. This is nearly as bright as the maxima which were observed during the interval 1915 to 1919, when the star reached photographic magnitude 8.4 on three occasions. Only a year has elapsed since the increase in brightness to magnitude 9.8 was noted in 1938 (see these notes, POPULAR ASTRONOMY, June-July, 1939) although an approximate periodicity of 650 days was then suggested. The variable requires careful attention, both as regards magnitude and spectrum.

More Supernovae: Dr. F. Zwicky at Palomar continues to find more supernovae in extra-galactic systems. The latest reported was found in NGC 6946 on a film taken on June 6, 1939. Its absolute magnitude would appear to be —11.9, slightly fainter than that previously found for novae of this type. This makes two supernovae found in this galaxy, another having been detected on a 1917 plate.

From an examination of a dozen or more light curves of supernovae compiled by Dr. D. Hoffleit—in a paper presented at a Symposium on Progress in Astrophysics at the American Philosophical Society in Philadelphia in February, 1939—it is clear that these stars do not present the diversity of form found for ordinary novae. All, apparently, have sharp maxima, although the ascending branch of the curves are by no means well defined. The average rate of decline for supernovae in the first thirty days after maximum is approximately a tenth of a magnitude per day, about twice as rapid as the average found for ordinary novae in the Andromeda Nebula.

Curiously enough, Dr. R. Minkowski, of the Mount Wilson Observatory, has been able to formulate a rule—once the type of post maximum spectrum has been observed—for determining the approximate date of maximum of the supernova, even though estimates of its actual magnitude at maximum are lacking.

The appearance of supernovae in extra-galactic systems, heretofore considered a rarity, has proven to be of great interest. NGC 3184 has yielded three such novae, and NGC 6946 and NGC 4321, two. Perhaps, of all the extra-galactic systems so far examined and found to possess supernovae, these three may be systems in which conditions are especially suitable for the production of such unique stars. Will more supernovae be found in these systems, as well as in others?

Peculiar Variables: A number of the peculiar variables continue to be of added interest. R Coronae Borealis, after a minimum magnitude of 13.5 in December, 1938, began a gradual rise to magnitude 8.3 in May, 1939. Since that time the variable, instead of becoming steadily brighter, underwent another decrease in light and by September 1 had dropped to the tenth magnitude.

RY Sagittarii, which was at minimum, magnitude 11.6, in November 1939, has, after several marked fluctuations in light, reached the seventh magnitude, nearly maximum brightness. SU Tauri and S Apodis remain at nearly constant bright-

ness, magnitudes 9.6 and 10.0, respectively.

SS Cygni was at maximum on August 6, 1939—a B-type maximum—sharp rise and of short duration. On August 15 SS Aurigae was at a maximum, but observations are still too few in number to define the type. U Geminorum should be at maximum soon again, the last one having been observed in February, 1939.

R Scuti passed through a deep minimum, magnitude 7.3, early in August. The last deep minimum was observed in June, 1938. Between these two deep minima the star varied between the magnitudes 5 and 6, more or less irregularly.

Current Novae: According to AAVSO observers, Nova Pictoris 1925 has decreased to magnitude 9.7, at a rate of about a tenth of a magnitude a year. Nova Herculis 1934 is now hovering around the tenth magnitude. There appears to be a wider spread in the observations of this nova than formerly. Whether or not this is due to the greater difficulty of obtaining a star-like image of the nova is a question. Dr. William H. Steavenson reports that the image of the nova now resembles more nearly that of a planetary nebula, difficult to bring to a point of light.

Nova Lacertae 1936 has faded away to magnitude 13.5, about three quarters of a magnitude in the past year. Nova (T) Coronae 1866 appears to have decreased from magnitude 9.5 to 9.8 during the months from May to September, 1939.

Nova Persei 1901 has oscillated between magnitude 12.2 and 13.1 during the past year. In recent years it has varied irregularly between magnitudes 12 and 14. Nova Aquilae 1918 hovers around the eleventh magnitude. Nova (RS) Ophiuchi 1898, which had a second outburst in 1935, continues to vary irregularly between magnitudes 10.6 and 11.6.

Dr. Steavenson, that indefatigable observer of faint novae, reports that observations made with his 20½-inch reflector during the year ending June, 1939, show other novae as follows:

Designation	Magn.	Designation	Magn.
Nova Ophiuchi 1848	12.7	Nova Cygni 1920	15.5
Nova Cygni 1876	14.7	Nova Aquilae (5) 1936	14
Nova Lacertae 1910	14.4	Nova Aquilae (6) 1936	15

WW Vulpeculae: The variable star WW Vulpeculae, 192121, was discovered by Ceraski in 1926. Kayama in 1931, from an extensive series of observations, suspected that the star might be of the Algol type, and Parenego in 1937, from Moscow plates, found the star to be usually bright and concluded that it was either an Algol star or of the R Coronae Borealis type. Lause in 1937 could find no satisfactory period and decided that in all probability the star should be relegated to the R Coronae Borealis class.

Dr. L. Jacchia has recently estimated the brightness of the variable on 1750 Harvard plates covering the past forty years and finds the total range of variation to be from magnitude 10.9 to 12.6, with maximum brightness being maintained for 100, 150, and even 200 days without the least indication of change in light. Minima occur at very irregular intervals and are of all possible depths, from $0^{M}.1$ to $1^{M}.7$. At times they appear deep and of short duration, lasting not more than 20 days, while at other times the light variations are found to extend over several years, during which time the brightness fluctuates fairly rapidly without having reached maximum phase. Miss Cannon finds the spectrum to be of class A2.

WW Vulpeculae shows similarities in its behavior to those of YZ Cephei (see these notes, POPULAR ASTRONOMY, August, 1939) and T Orionis, whose variations may possibly be associated with nearby nebulosity.

July-August, 1939, Observations: Herewith are listed the number of variables observed and number of observations contributed by each observer during the months of July and August, 1939; totals of 4579 and 4336 having been communicated during these respective months.

Name	July Var.	July Obs.	August Var.	August Obs.
Ahnert	37	287	33	164
Albrecht	..	..	20	44
Ancarani	..	..	9	10
Balwin	110	169	84	189
Ball, A. R.	13	14	..	..
Ball, J.	13	14	..	..
Bappu	30	88	24	50
Benini	..	..	1	5
Blunck	35	47	40	48
Britzelmeyer	..	..	2	6
Bouton	7	7	24	26
Brainard	1	1	..	..
Brocchi	23	33	91	140
Buckstaff	15	43	15	88
Cameron	..	..	8	8
Carpenter	..	..	5	5
Chandra	156	314	..	..
Cousins	43	152	38	104
Dafter	8	28	8	26
Diedrich	15	18	24	64
Economou	10	11	9	16
Ensor	59	116	53	66
Escalante	30	33	..	..
Fernald	59	150	74	165
Ford	43	43	..	..
Franklin	..	..	20	40
Gregory	113	158	97	160
Halbach	37	37	15	15
Hamilton	..	..	16	16
Harris	13	13	14	14
Hartmann	137	367	141	232
Hiett	20	25	18	33
Hildom	17	43	20	42
Holt	79	140	26	36
Houghton	80	115	..	..
Houston	..	..	64	140
Howarth	16	19	10	13
Jones	70	290	82	330
Kanda	3	33	..	..
Kearons	35	50	49	90
Kelly	17	25	12	30
Keuziak	5	6	..	..
Kirkpatrick	20	37	32	146
de Kock	60	230	58	212
Koons	25	27	37	47
Kozawa	12	24	..	..
Lizarraga	4	4	..	..
Loreta	145	480	170	631
Mages	15	21	..	..
Maupomé	14	14	6	6
McLeod	22	22	28	47
Millard	23	43	..	..
Moore	..	..	9	11
Murphy	..	..	8	8
Needham	42	50	50	90
Palo	12	37	14	23
Parker	43	50	40	43
Peltier	37	77	116	145
Peterson	3	7	6	28
Prinslow	5	5	14	19
Purdy	14	31	12	20
Rosebrugh	16	79	10	81
de Roy	10	60	13	34
Russell	23	42	26	65
Ryder	5	5	3	3
Salanave	..	..	8	8
de Santis	1	2	4	5
Schmid	14	17	9	9
Schoenke	2	2	13	27
Shafer	5	14	..	..
Shultz	16	16	..	..
Sill	52	52	21	21
Slocum	10	10	..	..
Smith, F. P.	11	11	19	31
Smith, J. R.	12	12	..	..
Stuart	13	13	..	..
Topham	24	24	89	92
Treadwell	18	47	14	21
Walton	13	38	5	11
Webb	11	11	21	24
Whittier	10	14	..	..
Williams	11	50	..	..
Williamson	14	14	..	..
Wright, B.	3	6	..	..
Yamasaki	21	21	14	14

September 11, 1939.

Notes from Amateurs

Notes from the Tulsa Astronomical Society

The Tulsa Society is starting on what we believe will be its best season thus far. The first regular meeting, September 12, presented an illustrated lecture by W. B. Whisenand, on "Astronomical Observations Applied to Aerial Mapping in

the Maya Country." Mr. Whisenand is a well-known map maker and aviator, and an authority on controlled mapping from aerial photographs. He was a member of the geodetic party on the widely publicized expedition through the Grand Canyon a few years ago, and has since then done extensive mapping in Guatemala, determining his latitudes and longitudes from the stars.

The Tulsa Society has increased its membership to about 50, and meets regularly the second Tuesday each month at the University of Tulsa. It is engaged at present, in coöperation with the University, in preparing plans for an observatory for Tulsa. Officers are: Jas. A. McBride, president; Eva Hirdler Greene, vice-president; Joel Burkitt, secretary; A. L. Jordan, treasurer; and Louis Desjardins, technical adviser. The Chairman of Publicity, R. L. Young, deserves mention also for his leadership in the observatory project.

Among the members who have made telescopes, in most cases including the grinding of the lenses and mirrors, mention should be made of Jas. A. McBride who has made a 4-inch refractor and an 8-inch reflector, G. E. Girouard who has made a 6-inch reflector, A. C. Francisco with a 10-inch reflector, and the following, the sizes of whose instruments I am unable to state at present, Dr. Ford Bridges, R. L. Young, A. Franey, and Harold Wood.

The *Tulsa World* publishes a weekly Sunday feature on "Astronomical Highlights of the Week," furnished by the society under the supervision of Mr. Desjardins. This appears under an art heading showing an observatory dome, with various planets, stars, comet, etc., to either side, and the skyline of Tulsa along the bottom.

Members of the society are engaged at present in special observations to determine the closest that Venus can be seen to the sun. It was at superior conjunction on September 5, having then a magnitude of —3, and lying about 2° north of the sun. We recently saw it plainly with the naked eye about 6° from the sun, and for about five minutes after sunrise. Using binoculars we expect to see it at half this distance, provided the sky is exceptionally clear. We recently saw Jupiter plainly with the naked eye as long as 30 minutes after sunrise.

On August 13, last, between 1:30 and 3:00 A.M., we counted meteors at the rate of exactly 200 per hour, and charted paths of 121.

Tulsa, Oklahoma, September 6, 1939. LOUIS DESJARDINS.

Communications and Comments

Under this heading we shall publish from time to time such material as does not properly fall under any of the established headings of this journal. Here, too, may be found, when occasion arises, articles which the editor may not be willing to give sanction to but which, nevertheless, may be provocative of thought along new lines.

Jumping Stars

During the past few months I have had the rare privilege of seeing "jumping stars" on two occasions. It has been suggested to me that you might be interested in a brief account of them.

On the night of February 20, 1939, or, rather, early on the morning of February 21 I had the pleasure of seeing two of these jumping stars. The day had been an excessively hot one for the time of year but after dark the temperature had

gone down rapidly so that by midnight the temperature was near normal for the season and it was quite cold between one and one-thirty A.M. during the time the stars were observed.

Vega, the star showing the fastest and most erratic motion, was only a degree or so above the steep side of a mountain behind which it was rising. In addition to showing rapid vertical and horizontal motions through an angular distance of about two degrees it had a circular motion which, most probably, was due to a combination of the other two motions which were taking place rapidly. All of the stars were unusually bright and scintillated more than usual. Vega, which also showed an unusual amount of scintillation, showed rapid changes in color. It would remain stationary for a few minutes at a time and then, suddenly, would begin to dart up and down in a vertical fashion or back and forth in a horizontal line. It might go through these motions several times and then begin to run around very rapidly in a circle having a diameter of about two degrees. These "jumpings" and circular motions continued until the star was perhaps ten degrees above the horizon. It was indeed one of the most interesting and uncanny phenomena I have ever witnessed.

At the time of the above observation Jupiter was almost opposite Vega but higher above the western horizon. About two A.M. we noted that Jupiter was showing considerable motion. Its motion was chiefly back and forth along a diurnal circle. Once or twice its motions were almost perpendicular to the horizon and perhaps twice it moved in an almost horizontal fashion. Once it must have "dropped" three degrees in one "jump." It did not show the most peculiar circular motion.

About six weeks after the above date, the night watchman of the college reported seeing the phenomenon a second time. This time he observed a star in the southern sky and another almost opposite it in the northern sky. On both of the occasions noted bright stars almost opposite each other were seen to jump. Since the night watchman does not know the stars by name and since he did not report this occurrence until some time after noting it, I cannot give a date or accurate information about the jumping stars, but I do not doubt this observation as he first called the matter to my attention in February and in May.

Two nights ago, May 9, about nine o'clock in the evening, I had the pleasure of watching for the second evening a jumping star. After a hot day there was a sudden drop in the temperature and by nine o'clock it was relatively quite cool. Sirius was low in the western sky and was showing appreciable motion. The sky was rather cloudy and not many stars were visible, but those which were visible were showing an unusual amount of scintillation. The cloud just below Sirius faded into the mountain top and made it difficult to estimate the distance of the star above the horizon, but it was, perhaps, about seven degrees above the mountain top. The star soon dropped behind a cloud so we were able to watch it only a very few minutes. Its motions were back and forth along an ellipse of very high eccentricity instead of back and forth along a line. The major axis of this ellipse was about a degree or slightly less in length. The star's motion in this ellipse was not quite continuous. Since the eastern sky was quite cloudy we were not able to determine whether a star opposite Sirius showed any motion.

Three accounts of jumping stars in the literature are known to me and are to be found in the volume of *The Observatory*, issued in 1888, number 141, page 385; 142, pages 404-405; and 143, pages 433-434. These are brief accounts of stars as noted in Australia, England, and India. There is also some reference to jumping

stars in the 1938 issue of this same journal, I believe, but this issue of the journal is not available to me so I cannot give the reference.

It was indeed a privilege to observe such unbelievable phenomena. The circular motion, in particular, was so incredible that had there not been three of us looking at it and seeing the same things each of us would have questioned our eyes or our sanity, or both. Two of us observed Sirius on May 9.

I should be interested in knowing whether it is customary to observe jumping stars in opposite parts of the sky whenever the phenomenon is observable and also whether convection currents in the air are responsible for the apparent motions of the stars on these occasions.

HARRIET H. FILLINGER.

Hollins College, Virginia, May 11, 1939.

NOTE: The size of the "jumps" here reported seemed so large that I questioned the writer about them. She admits that they seem incredibly large, but feels that they have not been exaggerated, according to her best judgment in estimating angular distances. EDITOR.

Sign Posts and the Earth's Magnetism

One of the puzzles of science is the cause of magnetism in the earth, that is, the magnetism that actuates the compass needle. I think I can show that the whole thing, including the variation in the deflection of the compass needle and all disturbances in the earth's magnetism can be explained almost solely by facts known more than fifty years ago.

These facts are sign posts pointing to scientific truths, but men have been stumbling over such factual sign posts for centuries. They have clung to the theory of light, the stationary, vibrating, exceedingly-elastic ether theory for centuries, though the ether just described is as impossible of conception as fourth to tenth dimensions so glibly spoken of and considered so essential in modern, stream-lined science, according to its votaries. Scarcely any of the phenomena of light can be made to comport with this universally-accepted theory.

Scientists have stumbled over the sign post revealed in the action of the moon in turning one face toward the earth instead of rotating as the earth does, or failing to rotate at all, even once a month, as astronomical mechanics, as at present developed, would assert as a possible condition. Even in the face of the fact that there is not a heavenly body known, that has no satellite of its own, that is not doing exactly as the moon is doing, scientists stumble over the facts and have no other explanation than the fatuous one that the moon, for example, just rotated more and more slowly until its period of rotation happened to be exactly the same as its revolution.

Scientists refuse to recognize the indisputable fact that when all the perfectly known forces are considered, including gravitation and centrifugal force, analysis shows that there are two large resultant forces that prevent any satellite that has not a satellite of its own from rotating with respect to its radius vector. I proved this in a contribution published in POPULAR ASTRONOMY, August-September, 1934. In spite of the editor's tacit invitation to discuss this, no response was forthcoming, and hence no one ventured to controvert my analysis of the forces.

Scientists have stumbled over the factual sign post that every heavenly body that has a satellite is rotating in the same sense as the satellite is revolving around it, and bodies having many satellites are rotating at greater speed generally, than those with a single satellite. In addition to this, if there is any fluid on the sur-

face of the primary, that fluid, at the equator, is moving more rapidly than the body itself. Examples: the rotation of the sun, Jupiter, and Saturn, greater in speed at the equator than near the poles; the equatorial current in the earth; higher ocean level in the Pacific than in the Atlantic at the Panama Canal. All of these facts point to the indisputable conclusion that some force or forces external to the primary are exerted on the primary to rotate it and force greater rotation in the equatorial belt. The force or forces are due to the satellite or satellites and could not have any other cause. It is inconceivable that in a heavenly body itself any condition could exist that would create a driving force at the equator forcing a flow of liquid matter ahead of the rotation of the body itself. It is equally out of the question that inertia on an equatorial belt could continue, against tremendous friction, to keep that belt in excess rotation for ages.

Incidentally the evident fluid condition of Jupiter and Saturn, exhibited by the facts above stated, prove these planets to be hot and not, as commonly stated, very cold. The belts of these planets change very slowly, a movement too slow to be atmospheric.

Scientists have stumbled over the factual sign post that no gaseous satellite of the sun (comet) is spherical. The obvious fact is that any gaseous body free in space must assume a spherical shape and not either of the other two shapes that G. H. Darwin asserts are conditions of stability of such bodies when revolving "infinitely-slowly," which is stationary. The two stable bodies mentioned by Professor Darwin are a thin, circular disc revolving "infinitely-slowly" about an axis through its center and normal to the disc and a long, thin cylinder revolving with the same "speed" about an axis at right angles to the axis of the cylinder. These are only two of the startlingly erroneous statements made by this author of high standing. There is positively no ground in mechanics of any kind for the idea that a fluid body in free space would take any other shape but spherical due to its own gravitation, and certainly the heavens do not furnish any example of any body or bodies resembling even remotely Professor Darwin's other "stable" forms.

I have shown in POPULAR ASTRONOMY, April, 1938, that a gaseous satellite of any heavenly body could not possibly remain in a spherical shape but must elongate exactly as comets elongate. No response has yet been brought out by the editor's invitation controverting my analyses. Men have viewed comets for many centuries, but scientists have failed to furnish us with any better explanation of the comet's tail than the one that attributes it to the "blowing" effect of the sun's light. But why does not the earth's extreme outer atmosphere act in the same way as the comet's rare constituents, and why does it not exhibit the luminosity of the comet's tail?

In the contribution in POPULAR ASTRONOMY, above referred to, I have given an explanation of the formation and the luminosity of the comet's tail. It is all based solely on laws and facts known for many years and proven by phenomena exhibited right here in the earth. It is not necessary to go to the stars and assume that some hypothetical possibility is back of action that is in no measure displayed in the earth, as the "atomic power" theorist must do, who tells us that in the stars matter is being transformed into energy.

One of the favorite ways of beating nature to a solution of one of her own problems is to assume that in the sun and stars electricity is doing tricks that it cannot be made to do in the earth.

Two facts observed or discovered more than fifty years ago, which make an explanation of the earth's magnetism a simple matter that anyone familiar with

the elementary things of electricity and magnetism can fully understand are these:

(1) In 1883 the volcano, Krakatoa, near the equator, erupted and sent dust twenty miles into the air. This dust was observed to circulate around the earth in the high upper atmosphere at hurricane velocity in an *eastern* direction.

(2) In 1876 H. S. Rowland proved that when a charge of static or frictional electricity is whirled around an iron core, the iron core will be magnetized, as the core would be magnetized when any electric current passes around it in a wire. This is the action in a house bell.

It has long been known that when certain substances are rubbed on one another static electricity is generated. The substances may be solid or gaseous. Winds on a cloud charge the cloud with electricity. Different layers of air moving on one another, by reason of some difference in their composition, generate static electricity. This is seen in a striking manner in the aurora borealis, as the swiftly-moving currents of air in the high atmosphere of the earth move toward the north pole, pushed forward by convection of the heated air of the tropics and the necessity of that air flowing in the only direction it can go to give place to more rising tropical air, namely north and south to the poles.

That the upper atmosphere is in layers is attested by the recently discovered fact that radio waves are reflected on the separating layers between the different strata of the earth's atmosphere.

Putting these facts together a full and complete explanation of the earth's magnetism is found. Around the tropical zone, in the high upper atmosphere swift currents of rarified air are encircling the earth, always in an eastern direction. The layers in this air moving on one another generate static electricity. The charges are thus continually whirling about the earth. The earth furnishes the iron core, as it is doubtless largely iron in its deep interior; and we have all of the conditions to make a magnet of the earth itself.

Since we have seen the direct connection between the moon and the earth's rotation and the rotation at greater speed, in the equatorial belt, of its fluid envelope the air, the variation in the magnetism is naturally explained by the fact that the moon's orbit is not in the earth's equatorial plane. When the moon is high north of the equator, the high equatorial winds encircling the earth are shifted from the course they take when the moon is on the equator or south of it.

This explanation of the earth's magnetism is a natural one and a logical one. It assumes nothing whatever that is not fully known unless it be that the center of the earth is largely iron. This is highly probable on account of the specific gravity of the earth itself which is about eight-tenths that of iron.

The idea that there is some mysterious electrical influence coming from the sun to the earth is not tenable. It assumes properties of electricity totally unknown in the earth.

The other idea that magnetism in the sun induces magnetism in the earth has no support whatever in fact. Ask any electrical engineer to take a two-foot ball and magnetize it in any way whatever and by so doing magnetize a ball the size of a pea 200 feet away. Magnetism vanishes entirely in the earth, when steel or iron is heated somewhat above incandescence, a heat much below the evident temperature of the sun.

EDWARD GODFREY.

Professional Building, Pittsburgh, Pennsylvania.

General Notes

A Few Stars of Large Proper Motion in a Northern Field

The stars listed below seem to be the best of about thirty stars of noticeable proper motion found by the writer in the examination of a field centered at R.A. $8^h\,00^m$, Decl. $+80°\,00'$. Harvard plates MC 19257 and MC 30187, with a scale of 1 mm equal to 98″.6 and an interval of 16.6 years, were examined in the smaller blink microscope of the University of Minnesota. The magnitudes given in the table below are photographic and are based on the Greenwich catalogue. The numbers given in the first column are those assigned during the search.

No.	B.D.	R.A. (1900)	Decl.	Mag.	Spec.	P.M.	Dir.
22	80°238	$7^h39^m.8$	+80° 31′	7.2	G5	0″.47	290°
19br	80 245	7 54.7	80 13	10.0		0.41	158
ft		sep. 113″		14.3		0.41	158
8		8 45.4	79 49	12.7		0.19	229
6		8 48.0	79 19	12.2		0.30	75
7		8 49.5	78 54	12.5		0.56	191
5	81 297	9 14.0	81 16	10.1		0.35	190

Attention is called to 19, a pair of stars, with common proper motion, separated by over one hundred seconds of arc.

This region has never before been examined with a blink microscope.

The writer wishes to thank Dr. W. J. Luyten for the use of the plates and the blink microscope and other invaluable help. He also wishes to thank Kasmer E. Dykoski for measuring the motions and reducing the measures.

University of Minnesota, July 26, 1939. NOAH W. MCLEOD.

Solar Halos

On June 12, 1939, several conspicuous solar halos were observed here. At one time there were four halos visible. Starting about 10:00 A.M. and continuing until 3:00 P.M., they attracted considerable attention.

EDGAR S. PASHBY.

1019 Fenimore Avenue, Kalamazoo, Michigan.

An Unusual Auroral Display

While travelling by bus through eastern Montana and western North Dakota, we witnessed, on the night of August 11-12, an auroral display far more impressive than any we had been privileged to see before. The phenomenon was unusual enough to keep a number of the passengers (among whom were several from northern United States) awake until after midnight; so it seems reasonable to conclude that such brilliance and duration is uncommon even in those latitudes.

The first streamers appeared in the north shortly after sunset near Forsyth, Montana, as a few narrow beams, perpendicular to the horizon, and apparently colorless. With the coming of darkness, the display spread both in altitude and azimuth, and the green color common to many aurorae became evident. The maximum stage began during a stop at Glendive (8:55-9:10 Mountain Time) where the streamers were seen to extend from the northern and the southern horizon, meeting near the zenith. They were to be observed at all points of the horizon, but those east and west were much less conspicuous.

After this, our seats on the left of the coach permitted principally a view only of the northern portion of the sky. Here events rapidly approached a climax with the appearance of "curtains." These were by no means as impressive as they are often depicted in drawings, nor were they multicolored; but several patches of deep red appeared at an altitude of 45°, the largest of which, though irregular in outline, could have been contained, roughly, within a square 10° on a side. At this time a low arc of dusky haze extended across the horizon. From its upper boundary the streamers shot vertically, brightened, faded, shimmered with the horizontal bands swiftly traversing their entire length. Those more stable patches of green and red, as well as the curtains, seemed to follow the curved upper outline of the dark arch.

Near 9:40, the highest portions began to fade rapidly. First to go were the red patches, then the green clouds and curtains, until, at 10:00 o'clock, only streamers, the longest of which reached halfway to the zenith, remained. Here the decrease stopped, and the phenomenon continued, still an arresting spectacle, until dawn—a few miles west of Jamestown, North Dakota.

PHILIP TAYLOR.

Flower Observatory, University of Pennsylvania,
Upper Darby, Pennsylvania, 1939 August 16.

Auroras of August 21 and 22, 1939

First observation was made at 9:00 P.M. on August 21, when bright active homogeneous arc was present about 23 degrees above horizon. It quickly reached to height of Polaris or about 42 degrees. The arc was well defined below and stars of third magnitude were easily visible through the dark segment. About 9:30 P.M. bands quickly spread across the sky from a point almost due northwest, through constellation Lyra and about 5 degrees in width, to the east as far as about 25 degrees above the horizon, brighter at both extremities than in the region of Lyra. Another shorter band paralleled it about 10 degrees south. At 10:00 P.M. the entire aurora disappeared and only a faint glow in the northeast lasted until observations ceased at 10:30 P.M.

On August 22 the display was very similar to that of the previous night, but not so large or so bright at any time, but at 9:15 to 9:30 P.M., or a little later, a much brighter beam stretched across the sky in almost the same position as last night. At approximately 10:00 P.M. it was very bright and looked like a giant comet stretching from Lyra westward to Arcturus and almost coming to a point at its west end. This display was all over at 10:15 P.M.

Another brilliant aurora was present on August 11, but owing to partly cloudy skies it could not be observed in detail. All above mentioned displays were coincident with large and numerous groups of sunspots during the month.

D. E. HADDEN.

Alta, Iowa.

Mars—1939

Astronomers situated near 40° north find that Mars, with its southern declination, is not a very satisfactory telescopic object. Even when near the meridian, Mars is too near the horizon to be above disturbing air waves, which seem to be worse than usual this summer. I began observing the planet during April, getting up in the after part of the night when the weather was favorable. Observations were made every clear night up to and after opposition when the planet was near the meridian. At times of good seeing, which were rare, definition was remarkably sharp and revealing.

The most salient feature was the melting ice cap with its attendant belt of water, then the Syrtis Major with its darkening point came next. I caught glimpses of Solis Lacus during one night of poor seeing when it was impossible to keep the planet in focus.

The most interesting feature observed was the coming and going of the northern cap before assuming a permanent existence. The apparent veiling was noticeable.

Unless seeing were good, identification of the lesser markings was not easy. The Margaritifer Sinus with its hump was easy but the Fastigium Aryn was difficult.

To avoid the well-known purple haze of refractors and the glare of the bright surface of the planet, a three-inch diaphragm was needed on the 5-inch lens, which greatly increased the sharpness of definition at all times. The powers used ranged from 100 to 385 with 225 preferable. Higher power was occasionally used but the unsteady air conditions usually rendered high powers useless.

Previous study of photographs and drawings of Mars rendered this series of observations much more interesting than would have been possible otherwise.

Hillsboro, Ohio, September 1, 1939. WILLIAM E. DUCKWALL.

Book Reviews

The Yale Photographic Zone Catalogs

"Transactions of the Astronomical Observatory of Yale University," Volume 11, just published, contains a catalog of 8101 stars, in the zone —10° to —14° declination, by Frank Schlesinger and Ida Barney. This is one of a series of photographic zone catalogs being produced under the direction of Dr. Schlesinger, and of which seven catalogs already published and one in press give positions and motions of over 62,000 stars covering 34° in declination. Plates have been taken for some 64,000 more stars, covering 29° in declination, three-fourths of which have been read, and the program includes another zone of 11° with 20,000 stars for which the plates are soon to be taken.

The work was started in 1913 at the Allegheny Observatory where plates were taken for these zones. It was transferred later to the Yale University Observatory and plates for succeeding zones have been taken there and at the Yale Southern Observatory at Johannesburg. The program covers all stars to the 9th magnitude and thousands fainter in more than half of the sky, and includes over 140,000 positions and proper motions. It is a repetition of all the catalogs between —30° and +30°, and between +50° and +60° declination produced some 40 to 50 years ago under the direction of the Astronomische Gesellschaft.

One of the most amazing features of this great work is that it is all being done at one institution, and that a university observatory with a limited staff. It is the first time such an undertaking has been possible. The catalogs, which it repeats, absorbed parts of the resources of fifteen observatories over many years, and a photographic repetition of the northern half of the sky along similar lines and including some 120,000 stars, now being carried out by the Astronomische Gesellschaft, has the coöperation of seven observatories.

Several important developments have made possible this unusual output. The most important of these is doubtless the development of the short-focus, wide-

angle doublet lenses and the use of large photographic plates.

The first experiments at Allegheny were made with a 3-inch doublet of 64-inch focal length, using 8x10-inch plates covering 25 square degrees of the sky and exposed 25 minutes each. The 120 plates covered the zone —2° to +2° twice over, each plate having 130 stars or more. The equations for the plate constants were linear with three unknowns for each coördinate. Terms of higher order were carefully investigated. The probable error of a position from two such observations is ±0″.16. A detailed description of these investigations is given in the introduction to Volume 4.

The possibilities of the wide-angle cameras were so clearly demonstrated by these experiments that coöperative plans were made to reobserve, by this means, all A. G. catalogs and their extension to the south pole. As stated above, the Yale program covers over half of the sky north of —30° declination, and is partly overlapped by the program of the Astronomische Gesellschaft which covers the northern hemisphere, using 5°x 5° plates, while the region south of —30° is being covered at the Cape Observatory, also using 5°x 5° plates. The possibilities of using larger plates were further shown in 1929 when 48 plates taken at Yale covered the zone +20° to +30° twice over, averaging 800 stars on a plate exposed 12 minutes, and again in 1932 when 64 plates taken at Johannesburg covered the zone —10° to —20° twice with 625 stars on a plate exposed 6 minutes. Time spent at the telescope for either of these zones covering some 20,000 stars amounted to some 20 hours spread over 20 to 30 nights during a year. In considering the amount of time spent in observing, however, it should be noted that the special meridian observations for the 1,100 reference stars for such a zone required parts of 100 to 150 nights. Moreover, the measuring of the plates is exacting and time consuming. Dr. Barney estimates the time required for visual observations of such a zone to be 470 nights of 10 hours each. The comparison is incomplete but it emphasizes the great saving of observing time by the photographic process.

Another important feature is the economy realized by using the Hollerith computing machines for certain parts of these reductions, as developed by Dr. Eckert. The A. G. positions are all reduced for precession to the epoch of the new catalog and the polar coördinates are converted into rectangular coördinates by use of the machines. This is a great saving over the older methods. Moreover the comparison of the measured and computed coördinates for each star allows the computations to be expedited by using differentials, and it makes possible also a rapid derivation of the final catalog right ascensions and declinations, and of the proper motions—a decided advantage over the astrographic catalogs which give rectangular coördinates only.

For the zone —10° to —20° a Ross 5-inch doublet of 81-inch focus was used with plates seventeen inches square. A grating over the objective produced measurable first order spectral images 3.4 magnitudes fainter than the central image, and only a few stars were too bright for measurement in this way. For some 500 stars between the 6th and 7th magnitudes both spectral and central images were used, and the comparison of these gave also the magnitude distortion, corrections for which were always applied.

Many double stars could not be read, more especially those with components 1″ to 8″ apart and differing less than two magnitudes in brightness. Corrections were applied for optical distortion of the camera, and the plate constants depend upon five terms in each coördinate, two of them being of the second order.

Residuals for the 1,117 comparison stars arranged on a composite plate gave

empirical expressions of terms to the third order, as an average distortion surface between the meridian and photographic positions. Probably some of this warp is in the meridian positions. It is a severe test. These small terms were applied. The probable error of a catalog position from two observations is $\pm 0''.120$ in R.A., and $\pm 0''.105$ in Decl. The final differences, Yale - Harvard, give also the proper motions in 42 years. Systematic corrections to the General Catalog are given both for the positions and for the proper motions. Many important features of the work are described in the introductions to Vols. 9 and 11.

While large plates are more difficult to handle and to measure they have a great advantage in the matter of comparison stars. For the A. G. repetition of the northern hemisphere special observations of 14,000 reference stars were taken on three different instruments. The Yale plates already reduced have been based on special observations of some 5,000 stars. This special meridian work is very expensive, and it has always added much to the photographic problem.

It has been a hope cherished by Dr. Schlesinger for many years that the Albany General Catalog of 33,000 stars would be sufficient for reduction of large plates, and that it would no longer be necessary to ask meridian observers for special observations of reference stars. The mean epoch of the General Catalog is about 1900, and its positions projected with proper motion to the present have probable errors of $\pm 0''.3$, whereas for observed positions at epoch the errors are only $\pm 0''.1$. The G. C. stars are not specially spaced and they have a large range in weights adding appreciably to the plate solution. It is found that for the zone $-10°$ to $-20°$ (1933), the weight of plate constants deduced from the special observed positions is five or six times as great as the weight with reductions using G. C. positions.

Although the G. C. positions are not suitable for plate reductions, such a need is being provided for by regular observations on the standard instruments carrying out the general coöperative plans of the International Union. Examples of this are the Greenwich and Cape observations, 1931-1937, giving accurate positions and motions for 100 stars per hour in each 10° of the region $+24°$ to $-30°$, quite sufficient for reduction of $10° \times 10°$ plates using a grating. And Washington is observing a list of standard stars of magnitude 5.5 to 8.5 rigidly spaced, 30 stars and more for each $10° \times 10°$ area in the zone 0° to $-30°$. Again, the Greenwich Catalog $+32°$ to $+64°$, giving accurate positions and motions for over 10,000 stars, is sufficient for $5° \times 5°$ plates.

Such observations of standard stars in broad zones included with observations of the fundamental stars throughout the meridian are closely tied to the fundamental system, and zone work based on such positions has a more rigid connection with the fundamental system than it is possible to get through special zone observation of reference stars. The zone $-10°$ to $-20°$ has less than 100 FK3 stars for direct comparison, and this is entirely too weak. Another advantage in reducing with standard lists of brighter and fainter stars is that stars of all magnitudes are brought more rigorously to a common system. This has not been possible before and it is important in the general study of motions. The outlook is that coöperation in meridian programs will provide positions and motions for future needs of large plates.

The Yale catalogs have been compared with the A. G. catalogs observed some 40 to 50 years earlier and provisional proper motions for all stars determined. Thus proper motions of faint stars in large numbers become available for general investigations. It should be remembered, however, that these motions contain the

systematic errors of the two comparison catalogs, and they are not homogeneous from zone to zone. For reliable statistical results they should all be reduced to some standard system of motions. A similar caution applies also to the catalog positions. The photographic positions reproduce too faithfully the systematic errors of the reference stars and it is difficult to derive rigid reductions to a standard system for narrow zones.

As indicating one important use of these new catalogs, Dr. Schlesinger has found that in a rereduction of the Astrographic Catalogs using the new positions and motions the weights of positions in that great catalog may be increased fourfold.

This work at Yale providing as it does for accurate positions and motions of over 140,000 stars, with its demonstration of the great economy and at the same time the high degree of accuracy realized in using wide-angle doublets and large plates, represents the most important development in positional astronomy of the present time. Possibly those of us working continually with star positions can best appreciate the value and the magnitude of this work, and can offer the best wishes to Dr. Schlesinger and Dr. Barney and their associates for its completion.

H. R. MORGAN.

Fabre and Mathematics, by Lao Genevra Simons. (Scripta Mathematica, Yeshiva College, New York City. $1.00.)

This small volume of one hundred pages, issued in January, 1939, is the fourth in the series known as The Scripta Mathematica Library. It consists of four distinct papers, the first title being the same as that given to the volume. The other three are: The Interest of Alexander von Humboldt in Mathematics; The Influence of French Mathematicians at the end of the Eighteenth Century; and Short Stories in Colonial Geometry.

The beginner in the study of mathematics will find in the first two papers much that is of interest and of inspiration. In these papers the two great scientists mentioned, who were not primarily mathematicians, pay tribute in very beautiful language to the part mathematics played in their work.

The other two papers are quite different from these as is indicated by the titles. They are essentially historical, and so appeal more to the mature student. The influence of European education and personalities, chiefly French, upon early American education is traced, and the special study in geometry at the four Universities, Columbia, Harvard, Pennsylvania, and Yale, is treated in some detail.

The book is recommended for both secondary school and college libraries.

Biancani's "Sphaera Mundi"

In the June-July number of POPULAR ASTRONOMY Pio Emanuelli writes on Biancani's *Sphaera Mundi.*

(1). In Signor Emanuelli's note there is an unfortunate typographical error: in the title of the third appendix to the *Sphaera, traditis* has crept in for *tractatio.*

(2). Signor Emanuelli quotes Biancani's statement that the Copernican system *Ecclesiastica authoritate, tamquam sacris literis adversa, inhibita est.* This statement is found on page 37 of the 1635 edition of the *Sphaera.* On page 210 of the same edition, in the *Selectorum librorum Bibliotheca,* Father Biancani, having recommended authors prior to Copernicus, continues: *his succedat Nicolaus Copernicus, qui praeter absurdam hypothesim de motu terrae eximius est Astronomus, sed nunc cum Ecclesiae facultate legendus.* This last statement, that Copernicus

"may now be read with ecclesiastical permission," should not be overlooked in noting the former.

(3). In *Isis*, vol. 28, pp. 364-365, Grant McColley suggests that Father Biancani was the first to use the term *telescopium* exclusively and repeatedly in an extended treatise.

(4). I have been asking myself if the fourth appendix to the *Sphaera* should not be listed as Biancani's third published work. In the 1635 edition of the *Sphaera* it has its own title page, preface, and pagination; it shows all the signs of having been printed with the intention of publishing it separately. The title is: *Constructio Instrumenti ad Horologia Solaria describenda per opportuni . . .*

(5). Pio Emanuelli is *Professore libero docente della Storia dell'Astronomia* at the University of Rome. He does not belong to the staff of the Vatican Observatory, as the address given in the June-July POPULAR ASTRONOMY might lead one to believe.

W. BURKE-GAFFNEY, S. J.

St. Paul's College, Winnipeg, Manitoba, September 5, 1939.

Compounding in the English Language, by Alice Morton Ball. (The H. W. Wilson Co., New York City. $2.50.)

At first thought it would seem that a book bearing this title has little, if anything to do with astronomy. Realizing, however, that astronomical theories and discoveries must be communicated by the same medium as any other intelligence, the correct use of that medium becomes important, and the volume before us is entitled to a place here as well as elsewhere. Especially in an editorial office does such a volume become a useful and necessary implement.

This book treats a somewhat restricted, though quite puzzling, phase of the use of English words. After an exhaustive study and comparison of the practice in compounding words by the recognized authorities in America and England, and after laying down logical rules to be followed, more than one hundred pages are devoted to an alphabetical list of compound words. It is this list which will be consulted frequently by those who are responsible for the form in which printed material appears.

The author, having been associated since 1925 with the Department of State, has had extended experience with exacting editorial work. Her volume, therefore, carries with it much weight, and may safely be regarded as an authority in its particular field. Users of this work will become increasingly indebted to her.

Beyond Yonder, by Oliver Justin Lee. (Chapman and Grimes, Inc., 110 Mount Vernon Street, Boston, Massachusetts. $2.50.)

This somewhat unusual yet quite suggestive title is given to a recently published, neatly bound volume of 170 pages. The natural and correct inference from the title is that the book deals with cosmic space and the numerous and expansive objects found therein. This places it in the category of astronomical literature.

But it is different from the conventional text in astronomy. The author has taken as his central theme an exposition of the scientific determination of distances. The range within which distances can be determined by direct measurement is narrowly prescribed. Very small, inter-atomic, distances and very large, intergalactic, distances, both can be ascertained only by indirect methods. By skillful use of experimental work in which he, as director of the Dearborn Observatory, is engaged and others with which he is in close contact, the author shows the reader the integrity of the method and the consequent dependability of the conclusions.

The prosaic, matter-of-fact style so commonly found in scientific books is noticeably absent. There is an interesting scattering of quotations, an effective use of illustrative material, and an intriguing collection of sketches and photographs. A few chapter headings will show what is meant: "Man Lives by Parallax"; "Private Interviews with Stars"; "Michelson plays with Light"; "The Cepheids whisper to Shapley." The thread of the development is not broken by inserting all the necessary but technical details. These are relegated to the appendix, to be studied by those readers whose curiosity prompts them to do so.

With a small amount of scientific training the reader will have an enjoyable experience in reading this volume, and, having read it, he will feel that he has come close to present day ideas and investigations which are giving direction to current scientific and philosophical thought.

Astronomy for the Layman, by Frank Reh. (D. Appleton-Century Company, New York City. $3.00.)

This is a rather tardy review, as this volume was published in 1936. It is one of a number of books on popular aspects of astronomy which have appeared in the last few years. The author, having taught astronomy to college students, has a background of experience for deciding upon the subject matter and method of presentation for such a book. One unique feature in this volume is the introduction of numerous poetical references to the topic under consideration. Nearly every page contains one or more brief passages from poems having bearing upon astronomical themes. The aptness of the quotations shows very extensive reading and painstaking collecting on the part of the author. The number of them impresses the reader with the large part this science has contributed to the thought of the poets both classical and modern.

The colume consists of Part I, The Starry Vault, comprised of fifteen chapters, and Part II, The Solar System, comprised of eight chapters. It is nicely bound, well printed, and replete with illustrations. In addition to numerous drawings in the text, there are fifteen full-page plates which reproduce in excellent manner astronomical photographs, which were made at the Yerkes, Mount Wilson, and Lowell Observatories. It is a volume well worthy of a place in any public and private library.

Transactions of the International Astronomical Union, Volume VI (1938). (Cambridge, England, at the University Press; New York City, The Macmillan Company. Price $7.00.)

This large and important volume is the official record of the Sixth General Assembly held at Stockholm August 3 to August 10, 1938, and was issued under the editorship of Dr. J. H. Oort, General Secretary, Leyden, Holland.

In commenting upon the preceding volume, reference was made to the steady increase in the size of the successive volumes as indicative of the increase in the scope of the work of this organization. This growth has continued in the present volume. The six volumes contain, respectively, 248, 288, 348, 328, 430, and 518 pages.

The organization of this volume is similar to the preceding ones. The two most extensive sections are naturally the one containing the Reports of Commissions, thirty-six in number, and the one containing the Resolutions Adopted. These sections constitute a handbook of current astronomical investigations in practically all fields.

The final pages list 554 names and addresses of astronomers, members of the International Astronomical Union. This, as well as the other parts of the volume, will be referred to many times because of its timely information. For this reason all users of it will find themselves greatly indebted to the editor for the care exercised and the stupendous amount of labor expended in the preparation of it.

No astronomical library should be without this useful and authoritative volume.

Men Who are Shaping the Future, by Edgar Middleton. (The Scientific Book Club, 111 Charing Cross Road, London, England. Price 2/6 to members.)

This volume was the choice of the Scientific Book Club of England for May, 1939. It consists of 238 pages of very interesting and instructive reading.

The author in the introduction states the thesis that the atmosphere and temper of the people in democracies is very much more conducive to scientific progress than in totalitarian states. He has written the volume as evidence in favor of his assertion.

There are eighteen chapters, each descriptive of the phase of scientific work fostered by an outstanding scientist. They are titled as follows: The "Grand Old Man" of Science (Sir William Bragg), The Medical Research Council (Sir Edward Mellanby), Joyous Adventurer (J. B. S. Haldane), A Family Affair (Julian Huxley), Frostology (Sir Joseph Barcroft), Story of Artificial Radium (Professor F. L. Hopwood), He Found Insulin (Banting), Prophet of the Stars (Sir James Jeans), The Underdog's Champion (Sir John Orr), A Scientific "F.E." (Sir Frank Smith), Darwin's Elisha (Sir Arthur Keith), The "Wealthy Amateur" (Lord Rayleigh), Story of Vitamins (Sir F. G. Hopkins), The Clerk of the Weather (Sir George Simpson), Pioneer of Television (John Logie Baird), Prophet of the Future (A. M. Low), Agricultural Research Council (Edwin John Butler), Unknown Soldiers of Science (Smith, Brown and Jones).

From this catalogue of topics it is readily seen that all of the major aspects of present-day scientific research are here represented. The volume thus affords the reader with an easy and pleasant method of bringing himself up to date scientifically.

The author selected all of the personalities in his list from those now active and living in the British Isles. This is entirely a natural procedure in the circumstances under which the book was written. He, doubtless, would be the first to agree that, if workers in the other democracies were to be included, the list would have to be greatly extended. The volume is a timely and a useful one.

National Geographic Society-U. S. Navy Solar Eclipse Expedition of 1937 to Canton Island.

The account of this expedition is summarized in Number 1 of The Solar Eclipse Series of the Contributed Technical Papers by the National Geographic Society. This paper-bound volume of about 130 pages consists of a foreword by Dr. Lyman J. Briggs, eleven technical papers relating to various phases of investigations carried out by the members of the expedition, and papers contributed by Dr. S. A. Mitchell and Captain J. F. Hellweg. A high grade of paper is used with the result that the drawings, photographs, and paintings are reproduced with great fidelity. Although this eclipse was one of the most inaccessible, it is doubtful whether any other eclipse has been so well recorded as this one is in this volume. It is an important contribution to the literature of total solar eclipses.

POPULAR ASTRONOMY

CONTENTS

OCTOBER, 1939

THE SIXTY-SECOND MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY, WITH PLATE IV, CHARLES H. SMILEY 407

THE LIGHT CURVES OF NOVAE, DEAN B. MCLAUGHLIN 410

UPPER ATMOSPHERE DENSITIES AND TEMPERATURES FROM METEOR OBSERVATIONS, FRED L. WHIPPLE 419

THE CALCULATION OF METEOR ORBITS (FORMULAS), C. C. WYLIE 425

Planet Notes for November, 1939 431

Asteroid Notes 432

Occultation Predictions 433

Meteors and Meteorites 434

Meteor notes from the American Meteor Society,—Contributions of the Society for Research on Meteorites: Meteorite falls and bright fireballs observed in Sweden in the last twenty years; The occurrence of platinum in meteorites; Representative appointed for the Sixth Pacific Science Congress.

Comet Notes 444

Comet 1939 *h* (Rigollet),—Periodic Comet Tuttle,—Comet 1939 *e* (Kopff),—Comet 1939 *g* (Brooks II).

Variable Stars 447

Variable star notes from the American Association of Variable Star Observers.

Notes from Amateurs 449

Notes from the Tulsa Astronomical Society.

Communications and Comments 450

Jumping stars,—Sign posts and the earth's magnetism.

General Notes 455

A few stars of large proper motion in a northern field,—Solar halos,—An unusual auroral display,—Auroras of August 21 and 22, 1939,—Mars-1939.

Book Reviews 457

The Yale Photographic Zone Catalogs,—Fabre and Mathematics,—Biancani's "Sphaera Mundi,"—Compounding in the English Language,—Beyond Yonder,—Astronomy for the Layman,—Transactions of the International Astronomical Union,—Men Who are Shaping the Future,—National Geographic Society-U. S. Navy Solar Eclipse Expedition of 1937 to Canton Island.

The principal articles of this magazine, beginning with Volume **15** (1907), are listed in the INTERNATIONAL INDEX TO PERIODICALS.

Y

407
410
419
425
431
432
433
434
444
447
449
450
455
457

re